APPENDIX V

IMPROVED CONSTRUCTION INVENTORY DOCUMENTATION

DALLAS/FORT WORTH ATTAINMENT DEMONSTRATION

APRIL 2000 REVISION

Note: some spreadsheets have been truncated to fit the word processor, and complete copies of the data are available from Mr. Sam Wells at (512) 239-1441 or swells@tnrcc.state.tx.us.

Documentation for the Dallas Diesel Construction Emissions (DDCE) Project

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Version 1.1
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Introduction

This paper defines and clarifies the new emission inventory for non-road diesel construction equipment emissions inventory used in the attainment plan for the Dallas-Fort Worth ozone nonattainment area. The goal of the Dallas Diesel Construction Emissions (DDCE) project is to improve upon the emission levels used in the Houston attainment plan. Previous inventories had been supplied by the U.S. EPA in their Non-Road Equipment and Vehicle Emission Study (NEVES). As such, the accepted method to model other years than the 1990 NEVES data was to apply growth factors from the Economic Growth Assessment System (EGAS); then technology reduction factors had to be applied to the grown inventories to model new federal emission rules such as those for compression cycle engines (diesels). Over the last year, however, a new method of calculating non-road emissions has been developed by the U.S. EPA. The NONROAD model, even though in a *beta* version, will be used for updating the attainment modeling (1995-6 base case and 2007 future case) for the Dallas area because the model has the best available science with regard to emission factors and treatment of activity data. Inputs to the model are described next.

Variables to Update in the Model

- ***Geographic County Coverage***.

  Collin
  Dallas
  Denton
  Tarrant

- ***Year***.

  1995 base year for the photochemical model (CAM-x)
  1996 equipment count data from Power Systems Research (PSR) for population file

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1999 base year for data collection - fiscal year 1999 beginning in September 1998
2007 projection for attainment of the ozone standard

- ***Environmental***. The NONROAD model works more like the highway emissions model, MOBILE, in that temperatures and fuel qualities can be modified to better reflect local conditions. For this project, we used the same temperatures as for a typical "ozone season day" as what is used for the Rate of Progress plans for on-road mobile sources. Fuel sulfur setting were left at national defaults - and should be changed if on-road diesel sulfur (0.050 % S) is intended to be modeled in the State Implementation Plan.

  Gasoline RVP: 6.8
  Gasoline oxygen weight: 1.0
  Gasoline sulfur content: 0.034
  Diesel sulfur content: 0.330
  Minimum temperature: 77
  Maximum temperature: 102
  Average temperature: 93
  Altitude region: Low

- ***Equipment Populations***. The main change to the NONROAD model input stream was use of new equipment populations for diesel construction equipment. The TNRCC worked with representative construction operators through independent engineering firms. The general approach is to define market share of the representative construction companies and then upscale the equipment totals based upon estimated total market share. Survey methods and designs to incorporate locally-specific data are attached (see appended material). Local equipment data then had to be adjusted to state equipment populations using adjustment factors, since NONROAD requires statewide totals to perform the county-based calculations. These procedures are clarified in following sections.

  Equipment type: construction, source category code 2270002***
  Fuel type: diesel only
  Horsepower range: only those >25 HP are modified

- ***Other***. Annual hours of use was also updated for certain equipment categories, although the adjustments were fairly minor in magnitude. No other adjustments were made to the

NONROAD model's input files.

Method to Predict 1995-6 and 2007 Inventories

The general approach for modifying NONROAD's population files is described in the User's Guide.[1] The base year for equipment populations is the 1996 data compiled by Power Systems Research, Incorporated as allocated to Texas. Only diesel construction equipment over 25 horsepower were modified. Once the 1996 inventory of equipment is totaled for each category, the numbers were up scaled to statewide Texas numbers which were then entered into the TX.POP population file.

Then, using the NONROAD's internal logic for emission factor phase-in and equipment population growth, 1993 and 2007 emissions were generated. Output can be specified as a summary data base report (see appended material) or as encoded input for the photochemical model (EPS2 model output feature, not included due to its large file size).

Upscaling Local Equipment to Statewide Total Populations

Step 1. Estimate County-Specific Adjustment Factor. For the DDCE project, equipment were largely derived from an intensive study done in the Houston nonattainment area (Houston Diesel Construction Emissions [HDCE] Project). Exactly the same method was employed in the DDCE project. The steps are illutstrated by Houston's example.

The NONROAD model not only reports on emission levels but can also report numbers of equipment units for a given area and year. Use this feature to compare statewide and county-specific equipment populations - by writing down the numbers or using the EXCEL export feature and/or SAS. This step is required because NONROAD allocates county populations from a statewide total so any new data needs to be ratioed to a state total. In our Houston example, the statewide total averaged about 4.8 times higher than that for the 8-county area; this is the same as saying that NONROAD allocates about 20 percent of the statewide equipment in any given category to the Houston ozone region. Note: the allocation (.ALO) files could probably be used as a shortcut. The method used in this paper was to use a line-by-line analysis, where and adjustment factor would be derived:

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[1] ENVIRON International Corporation. 1998. *User's Guide for the National NONROAD Emissions Model*. Draft Version. June, 1998. Prepared for the U.S. EPA. P. 6-30.

$$adj_{frac} = default_Texas_{pop} / default_Houston_{pop}$$

equation 1

This adjustment factor (adj_{frac}) which was about 4.8 is kept constant and applied to the new Houston equipment population numbers ($new_Houston_{pop}$) to arrive at a new Texas statewide number (new_Texas_{pop}):

$$new_Texas_{pop} = adj_{frac} * new_Houston_{pop}$$

equation 2

Step 2. Format Spreadsheet for Texas Population File. The NONROAD model is organized by sequential, ten-digit source category codes (SCC) and then divided into horsepower ranges such as 16-25, 25-50, 50-175, 175-300 horsepower. Currently, NONROAD has several holes in the horsepower categories, such as trenchers (e.g., jumping from 175 to 300 horsepower), but the format must be exactly the same as what is used in the model. The file SUMTABLE.XLS was used in this Houston construction equipment project. The SCC's were all in the 22700-02*** series.

Step 3. Enter in Locally-Specific Data. Using bottom-up surveys, panels of experts, and market share surrogates, enter the new entries by SCC and horsepower. In the SUMTABLE.XLS file, the column is entitles "RICK_POP." Compiling the absolute number of pieces of equipment must be performed independently and well before this stage of processing. The final column in SUMTABLE.XLS shows how the local file is multiplied by the adjustment factor to generate a new statewide number, here called "NONROAD."

Step 4. Transfer Spreadsheet of NONROAD Input. To avoid corrupting the original NONROAD population file, it is saved to another filename called TX_HOU.POP. The new filename had to be entered into the NONROAD's master input file, which is named TEMPLATE.OPT. A DOS-text editor (QEDIT) was used to over-write the entries for each applicable row (only diesel construction equipment over 25 horsepower). Automated spreadsheets or SAS programs could be used, but since NONROAD is a FORTRAN program, we run the risk of truncating data by being one space out of sequence, so a manual approach is recommended. Only the eight-county emissions is being output so as to prevent the new population file from being applied to other areas within Texas. This requires us to rename the new Texas statewide equipment population such as to TX_HOU.POP from TX.POP.

Step 5. Perform Quality Assurance (Q/A) Checks. As a quality assurance measure, the

new statewide populations were run in NONROAD to verify that the local data was in fact used and that the model did not cause any bias or unexpected results. For example, the author's first efforts with the SUMTABLE.XLS spreadsheet consistently found that over 3,000 pieces of equipment were missing when the NONROAD output was compared to the input data. This major discrepancy was corrected; minor glitches, such as mistaking "scrapers" for "graders" with the mining and landfill data were not. Such Q/A checks would include:

- NONROAD output must be within 5% of input data
- new statewide total must be proportional to local data (see bottom row of SUMTABLE.XLS) within 2.5%
- calculation cells in the spreadsheet must be consistent from top to bottom
- comparison of default and new emission populations must be reasonably explained

Step 6. Record and Analyze Emission Levels. Examine new local emissions by pollutant and SCC and year. Compare the default and new data to external data used in the State Implementation Plan, Ozone Transport Assessment Group (OTAG) inventory, and other external sources to help explain the results. Utilize the EPS2 output feature if performing photochemical and/or aerosol modeling.[2]

Updating Annual Hours of Use

The file ACTIVITY.DAT was modified using the new annual operating data provided by Eastern Research Group (ERG) surveys. The following changes were made:

[2] It was discovered in the course of this study that NONROAD has an error when the user asks for a "typical ozone season day" in an EPS format; the solution was to divide the emission level in the EPS output by 91.21.

Table 1. Modified Activity Data, Hours per Year

Source	Default	Updated
Pavers	821	672
Rollers	745	533
Scrapers	914	455
Paving Equipment	622	344
Surfacing Equipment	561	708
Signal Boards	535	528
Trenchers	593	897
Drill Rig	466	1548
Excavator	859	833
Concrete Saws	580	508
Motor Graders	821	750
Off-Highway Trucks	1641	1257
Rough Terrain Forklifts	662	1041
Rubber Tire Loaders	761	1068
Tractor/Dozer	899	466
Backhoes	1135	745
Crawler Tractor	936	839
Skid Steer Loader	818	851
Off-Highway Tractor	855	853
Other Construction Equip.	606	536

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Findings

Oxides of nitrogen (NO_x) are reported in Table 1 below.

Table 2. NO_x Emissions, Tons Per Ozone Season Weekday

Scenario	Default NONROAD	Updated NONROAD *
1995 Base Case	133.26	49.55
1996 NONROAD Run	135.66	50.33
2007 Attainment Inventory	120.52	44.98

* Note: changes in hours of annual operation are included in these estimates

Supporting Documentation

- Input files: DFW_95.OPT, DFW_96.OPT, DFW_99.OPT, DFW_07.OPT
- Alternate activity file: ACTIVE_2.DAT
- Population calculator spreadsheet: SUMTABLE.XLS
- Alternative population file: TX_DFW.POP
- Output file: DFW_95.OUT. DFW_96.OUT, DFW_99.OUT, DFW_07.OUT
- EPS2 photochemical emissions files: EPS_D_96.OUT, EPS_D_07.OUT

Conclusions

The method to prorate local non-road equipment populations using statewide totals is not straightforward or easy, but it is possibly the only way to incorporate local activity data into the NONROAD model. Hopefully, this paper shed some light on the subject. Suggested in future revisions of NONROAD is the ability to over-ride statewide defaults by being able to directly over-ride the county-specific data. Until that time, the adjustment factor method is probably the best approach.

Attached is documentation written by Eastern Research Group (ERG) regarding how they collected the numbers used in the population and activity data files, including scaling factors based upon market share.

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Acknowledgments

- Eastern Research Group
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- Chris Lindjiem, consultant
- Association of General Contractors (AGC)

Dallas Diesel Construction Emissions (DDCE) Project

Development of a Revised Emissions Inventory for Construction Equipment in the Houston-Galveston Ozone Non-Attainment Area

DRAFT REPORT

March 20, 2000

Prepared for

The Houston-Galveston Area Council and the TNRCC Area and Mobile Source Emissions Assessment Section

Prepared by

Rick Baker
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Dallas Diesel Construction Emissions (DDCE) Project

INTRODUCTION

Under contract with the Houston-Galveston Area Council, Eastern Research Group conducted a detailed survey of construction equipment populations and activity within the 8 county Houston ozone non-attainment area.[3] As part of this effort, Starcrest Consulting facilitated communications with a coalition of local construction trade organizations and assisted with the development of survey strategies.

Based on the study's findings, input files were generated for use in EPA's NONROAD emissions model in order to estimate total pollution levels from construction sources operating in the area. These results serve as an update to TNRCC's previous estimates based on EPA's default methodology.

TNRCC staff recently ran the NONROAD model using the revised input files to develop a revised construction emissions inventory for the Houston area. The draft results are summarized below for emissions of nitrogen oxides (NOx), a key pollutant in ozone formation in Houston.

Table 1
Summary of Houston Construction Source NOx Emissions Estimates for 2007

Data Source	NOx (TPD)
EPA Default (NEVES)	101.6
Houston area study	37.4*

*Note that the results are under review by the TNRCC and may be revised.

Based on these findings, EPA's default methodology significantly overestimates total emissions from construction sources operating in the 8 county Houston area. Overall contributions to ozone formation from this sector are likely to fall as well, pending the results of future Urban Airshed Model runs.

The following sections provide a brief discussion of background issues, an overview of the study's general methodology and assumptions, detailed discussions for each construction sector evaluated, a summary of the study's findings, and recommendations for additional improvements to the inventory.

[3] Counties include Brazoria, Chambers, Fort Bend, Galveston, Harris, Liberty, Montgomery, and Waller.

Dallas Diesel Construction Emissions (DDCE) Project

BACKGROUND

The 8 counties in the Houston-Galveston region are currently designated as a severe ozone non-attainment area. As such, USEPA requires the Texas Natural Resource Conservation Commission (TNRCC) to adopt aggressive, stringent emission control strategies in order to bring the area into attainment with the National Ambient Air Quality Standards by 2007.

In order for the TNRCC to develop an effective control strategy for Houston, a detailed inventory is required for all emission sources in the area. Detailed assessments have been performed previously for both stationary and on-road mobile sources, using locality-specific data. For this reason population and activity levels for these sources are considered relatively accurate.

However most non-road source inventories, such as those for construction and industrial equipment, rely on "top-down" methods to estimate equipment populations and usage. Specifically the current estimates for non-road equipment populations in the Houston area are based upon EPA's 1991 Nonroad Engine and Vehicle Emissions Study (NEVES). The NEVES was developed from the Power Systems Research (PSR) national database of engine sales and populations, as well as from confidential manufacturer reports. The key parameters used to calculate NOx emissions for each equipment type include:

- equipment population;
- average horsepower rating;
- average engine load factor;
- annual hours of operation; and,
- emission factors.

For the NEVES EPA estimated county level equipment populations by allocating the national level data, using construction activity surrogates from the Census Bureau's County Business Patterns Report of 1991.[4] For further details concerning the NEVES data please see Appendix A.

For several reasons it is believed that the NEVES significantly overestimates equipment populations (and therefore emissions) for the construction sector in Houston. For example, Houston serves as headquarters for some of the world's largest construction companies, with thousands of employees dedicated to engineering and administrative work. However, the employment surrogates found in the County Business Patterns Report do not distinguish between "office" and "field" employees. While the number of construction field employees in a given area may be indicative of overall construction activity, projections using total "construction employment" in the Houston area may drastically overestimate overall equipment numbers and

[4] EPA currently believes this allocation scheme can be improved, and uses "dollar value of construction" estimates from the F.W. Dodge database in the NONROAD emission factor model currently under development.

activity. (Similar problems also arise with the F.W. Dodge data on construction valuations – see footnote 2.)

For these reasons a "bottom-up" survey of construction sources in the area could provide significant improvements to the equipment inventory. However, previous survey attempts encountered very low response rates, and ultimately proved unsuccessful.

As part of a multi-task contract with the Houston-Galveston Area Council, Eastern Research Group agreed to perform a comprehensive survey of all construction equipment activity in the 8 county area. In order to improve survey response rates, ERG obtained assistance from a coalition of several local trade organizations, termed the Houston Construction Industry Coalition (HCIC). The HCIC, along with their representative Starcrest Consulting, was instrumental in identifying key experts for interviews, as well as encouraging their member companies to actively participate in the survey effort. Table 2 lists the key trade organizations participating in the effort, along with their associated constituents. The table also lists key points of contact for additional survey sectors not represented by the HCIC

Table 2
Principal Contributors to Data Gathering -- HCIC and Other Participants

Organization/Point of Contact	Associated Sector
Associated General Contractors of Texas	Highway / Municipal Utility / Commercial
Associated Builders and Contractors of Houston	Industrial
Houston Contractors Association	Municipal Utility
Greater Houston Builders Association	Residential
Harris County, Judge's Office	Municipalities and Counties
Harris County Tax Assessor's Office	Rental
Equipment Purchasing Manager, TXDOT	TXDOT Equipment
Reliant Energy, Substation Construction Dept.	Utility Extensions

These organizations were also instrumental in developing the final survey and QA strategy, described in the following section.

METHODOLOGY

Equipment Categories

In its most recent emissions modeling the TNRCC adopted a hybrid approach, using the NEVES data to establish equipment populations, while employing EPA's draft NONROAD emissions model to account for future year growth and fleet turnover effects. For the current effort, ERG agreed to provide the TNRCC with updated, locality-specific input files for equipment populations and activity levels, as per the construction equipment classes designated in the NONROAD model. The TNRCC would then use these files in the NONROAD model to revise the tons per day emissions estimates for the construction sector.

ERG limited its data gathering to diesel engines greater than 25 horsepower operating in the 8 county area. Based on NONROAD model outputs using default parameters, diesel engines less than 25 hp emit less than 1% of total NOx emissions for this sector. Similarly, gasoline, and other fuels such as LPG, generate extremely low NOx emissions for this sector (~5%). For these reasons data gathering focussed on larger diesel engines. The specific NONROAD equipment categories of interest are listed in Table 3 below.

Table 3 - NONROAD Diesel Construction Equipment Categories

Description	SCC #
Pavers	2270002003
Plate Compactors*	2270002009
Rollers	2270002015
Scrapers	2270002018
Paving Equipment	2270002021
Surfacing Equipment	2270002024
Signal Boards/Light Plants	2270002027
Trenchers	2270002030
Bore/Drill Rigs	2270002033
Excavators	2270002036
Concrete/Industrial Saws	2270002039
Cement and Mortar Mixers	2270002042
Cranes	2270002045
Graders	2270002048
Off-highway Trucks	2270002051
Crushing/Processing Equipment	2270002054
Rough Terrain Forklifts	2270002057
Rubber Tire Loaders	2270002060
Rubber Tire Tractors/Dozers	2270002063
Tractors/Loaders/Backhoes	2270002066
Crawler Tractors/Dozers	2270002069
Skid Steer Loaders	2270002072

Off-Highway Tractors	2270002075
Dumpers/Tenders*	2270002078
Other Construction Equipment	2270002081

* Categories are entirely < 25 hp according to NONROAD.

ERG relied upon PSR equipment definitions of the above categories in order to facilitate the survey process. PSR categories, as presented in the NEVES study, are provided in Appendix B.

Use Categories

In consultation with the TNRCC, the HCIC and ERG attempted to identify all significant activities that utilize the diesel construction equipment listed in Table 3 above. These categories are summarized below.

1) Heavy-Highway
2) Municipal Utilities / Public Works Projects
3) Single and Multi-Family Residential
4) Commercial Building Construction
5) Industrial Maintenance/Turnarounds
6) Port activities
7) Landfills
8) Mining
9) Logging

Of these categories, the TNRCC were to provide estimates for landfills, mining, and logging activities. In addition, Port activities were estimated independently by Starcrest Consulting under a contract with the Port Authority. The remaining categories were estimated by ERG as part of this study.

After further consultation with members of the HCIC, Starcrest staff compiled a detailed description of each of these sectors (see Appendix C). As the study evolved, it became evident that additional stratifications would be needed to complete the assessment. The final construction sector categories evaluated in this analysis are summarized below.

Table 4
Construction Equipment Use Categories

Category	Key Constituents
Heavy-highway	General Contractors, subcontractors
Municipal Utility / Public Works	General Contractors, subcontractors
	Municipalities, Counties, TXDOT
Industrial	Capital, maintenance, and turnaround contractors

Commercial	Developers, contractors (includes multi-family construction)
Residential	Single family developers, contractors
	Utility Extension Contractors
Rental	Equipment Leasers, retail/wholesalers

Survey Candidate Selection

ERG worked closely with the HCIC and Stracrest to identify and contact owners of equipment in each of the categories listed above. For most of the categories, ERG adopted a stratified sampling approach designed to survey the largest users of diesel construction equipment within each sector.

The first step in this process was to identify "surrogates" for each category of interest. Surrogates served two purposes in this analysis. First, they provided a quantitative method of assessing the relative importance of the different equipment owners within a sector. Given resource constraints, it was not possible to survey every equipment operator within a given sector. Therefore only those contractors/subcontractors with the highest surrogate "rankings" were selected for surveying.

Surrogates were also used to extrapolate equipment populations to the non-surveyed portion of each use sector. For example, surveyed highway contractors comprised approximately 70% of the total contract lettings for the period of interest (see Heavy-Highway section below). Therefore surveyed equipment numbers, by type, were divided by 0.70 to estimate the total number for the entire highway construction sector. (The following sections provide a detailed discussion of surrogates and survey responses for each of the sectors.)

HCIC representatives maintain that this is a conservative basis for extrapolating populations and activities to each sector as a whole. An estimator from the heavy highway sector reasons that smaller contractors with fewer pieces of equipment do not have the job volume available to them to optimize the use of their equipment over time.[5] Therefore smaller contractors not included in the survey will necessarily have a greater percentage of down time for each piece of equipment, on average, per contract dollar let. This effect would tend to inflate the hp-hrs (and therefore emissions) attributed to the non-surveyed portion of each sector. Preliminary results from the NESCAUM off-road equipment study also indicate a similar trend for companies in the northeast.[6]

[5] Bob Lanham, President, AGC of Texas, Highway, Utilities, and Industrial Branch, personal communication, February 9, 2000.
[6] Chris Lindhjem, Consultant, personal communication, December 9, 1999.

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Survey Development and Procedure

Once surrogates and associated source rankings were established for each sector, HCIC representatives helped establish a final survey list and points of contact for those equipment users to be surveyed. In most cases ERG was able to contact estimators, field and/or equipment managers, or other personnel familiar with the actual use of equipment in the field. Upon initial phone contact, each equipment user was informed of the nature of the project, and that all information provided to ERG would remain confidential – that is, summary data reported to the TNRCC could not be linked to a specific company or individual. ERG adopted this provision at the request of the HCIC, to protect the proprietary nature of certain data, such as subcontracting costs, equipment ownership and utilization rates. The Confidentiality Agreement provided in Appendix D summarizes the procedures adopted to maintain the privacy of survey respondents.

After establishing initial contact, ERG provided each equipment user with a copy of the survey form via fax. Individual survey forms were developed for each sector, seeking the following information for each piece of owned equipment operating in the 8 county area and falling into one of the target equipment types. (The 1999 fiscal year -- Sept 1, 98 through Aug 31, 99 -- was selected as the base year for most activity assessments.[7])

- NONROAD Equipment classification;
- Horsepower;
- Engine model year;
- Estimated hrs/year, with basis for estimate;
- Surrogate data.

In addition, each survey form requested information to facilitate QA of the data received. The following provides a brief discussion of the nature and purpose of each type of data requested in the survey. Appendix E also provides a copy of the survey forms used for each sector.

Engine Horsepower -- Perhaps the single most important input parameter in the NONROAD model is engine horsepower. The horsepower rating determines the appropriate emission rate as well as the phase in schedule for future year emission standards. For this reason ERG went to great lengths to accurately determine the power rating of as many surveyed engines as possible. During the survey process ERG found that the majority of engine owners and operators did not know the rated power of their equipment, only the make and model. In these instances ERG collected the engine year, make and model data, cross-referencing the specific horsepower data in the Rental Rate Blue Book (1999, Data Quest Publications). Nevertheless, approximately 24% of the surveyed equipment lacked adequate make/model information and were assigned horsepower ratings based on the average NONROAD values for the given equipment category.

[7] Calendar year 1999 was used for some sectors when fiscal year data was not available.

Engine Classification -- All survey respondents were asked to categorize each piece of equipment according to the classifications listed in Table 3 above. The specific equipment category is used in the NONROAD model to assign default engine load factors and activity estimates. However, due to a lack of standardization in the industry it was often unclear how to assign certain pieces of equipment. For example, small excavators and backhoes serve essentially the same function in the field, and may have no significant distinguishing feature from the owner/operator perspective. Therefore ERG established a set of assignment "rules" for those pieces of equipment of indeterminate category. These rules are summarized at the end of Appendix B.

Potential "mis-assignment" of equipment under this scheme should not cause major errors, however. Specifically, NONROAD's load factors are fairly similar from category to category (from about 0.5 to 0.65 for the categories of interest). In addition, although default hr/yr values can vary significantly between categories, ERG was able to obtain engine-specific activity data for the majority of engines, thereby minimizing the need to rely on NONROAD default values.

Equipment Activity (hrs/yr) -- ERG requested usage data in hours per year for each piece of equipment surveyed. Activity estimates were based on a number of sources, including engine clock hour data, labor records (e.g., hours for crane operators), estimator or field supervisor estimates, and fuel use records. The accompanying spreadsheets note the basis of these values for each respondent. ERG obtained some sort of engine-specific estimate for activity for 68.4% of the equipment surveyed. When activity estimates were not available, ERG relied upon default values from the NONROAD model for a particular equipment category.

Equipment Age -- ERG requested model year for each piece of equipment. This information was the easiest to obtain from respondents as a whole, with a response rate of over 90%. Although this data was not used in the subsequent NONROAD model runs, it could be used to modify the model's default scrappage curves in the future.

Subcontractor Equipment Activity -- Equipment owners were asked to identify subcontractors using targeted equipment during the period of interest, along with the associated surrogate value (e.g., contract value). These subcontractors were subsequently contracted and surveyed in a similar fashion. (Rental companies and the Municipalities/Counties were excluded from this process).

Surrogate and Quality Assurance Data --[8] ERG also requested assorted information from each respondent to facilitate extrapolation and QA of the data. Much of this information was qualitative, based on expert opinion rather than quantified data, and is therefore subject to greater levels of uncertainty compared to the equipment characterization data discussed above.

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[8] Rental companies were not asked for this information, as they do not control the day-to-day operation of their equipment, such as fuel use.

The following provides a short summary of the additional types of data gathered by the survey.

- Surrogates – Quantitative measures of company/organization market share or related metrics were obtained for every survey respondent. If a company/ organization operates in more than one sector (e.g., highway and utility), estimates (either quantitative or qualitative) were obtained for activity splits between sectors;
- Fuel Use – ERG requested data on the fuel used by surveyed equipment. This data can be used to assess the average load factor of an engine by estimating average gallons per hp-hr values.[9] In general, fuel data were available for most of the highway and municipal utility contractor sectors, and several of the counties and municipalities. Fuel use data was sparse for the Industrial respondents, and non-existent for the rental sector. Since fuel consumption records are seldom available at the equipment level, estimates were generally provided for total fuel use per month or year, based on either purchase records or expert opinion. ERG attempted to account for fuel used in non-surveyed equipment, such as industrial equipment or engines <25 hp when possible. However, fuel consumption estimates per hp-hr are likely to be overestimated for this reason;
- Base Year Representativeness – All respondents were asked if they believed the 1999 fiscal year was representative of "typical year" operations. The vast majority indicated affirmatively, or reported that activities were significantly higher than normal. However, given the qualitative nature of this question, ERG did not perform a detailed assessment of the responses;
- Temporal Allocation -- Each equipment owner was asked to characterize the typical period of operation on a daily, weekly, and seasonal basis, by equipment type. Although response rates were low for this question, most respondents indicated that use did not vary by equipment type. In addition, the responses received seem to support the default EPS profiles showing uniform weekday activity during the day, with significant drop-off during the weekends;
- Geographic Allocation -- Each equipment owner was asked to report the location of their activities during 1999. While this information is available for the highway sector, the municipal utility and other sectors indicated that their operations were too numerous to report. Therefore the TNRCC will develop alternative means of geographic allocations;
- Use vs. Equipment Age -- Originally TNRCC staff expressed some concern that the NONROAD model did not apply age-specific activity factors for its tons per day estimates. Given data on activity variation with age, the NONROAD modeling procedure might be modified to reflect this variation. Therefore each equipment operator was asked if they used older equipment any differently than newer equipment. While some responses indicated that older equipment had greater down-time and therefore had lower activity rates, a sensitivity

[9] Modifying the NOROAD files to reflect new load factor data is a complicated procedure, entailing the revision of the model's scrappage curves, and was not attempted during this study. See "Findings and Recommendations" for further discussion.

analysis cutting the average useful life in the NONROAD model by 25% resulted in only a 3% change in overall emissions.[10] Therefore it should not be necessary to differentiate activity rates as a function of age in the model;

- Need for Additional Stratifications -- Each equipment owner was asked to identify other factors that significantly effect equipment operations, such as soil type, grade, etc. Aside from rain, no further stratifications were identified;
- Purchase Date and Location -- Each equipment operator was asked for the percentage of their equipment purchased before 1990, and the percentage purchased outside the 8 county area. TNRCC requested this data to facilitate an independent QA check of equipment populations using an alternative data set. However, most respondents indicated that they did not have ready access to this information, providing qualitative "guesstimates" at best.

Data Compilation

After receipt of the survey, each equipment owner was contacted by ERG representatives to set up an on-site interview. Although some respondents preferred to complete the surveys on their own, ERG found the on-site interviews were the most efficient means of gathering data, minimizing the need for additional clarifications with the respondents.

After survey completion, survey forms from private companies were sent to Starcrest Consulting, where identifying information such as company name was removed. Starcrest then assigned an ID code to each response and forwarded the modified surveys back to ERG for compilation and QA. This coding process followed the terms of the Confidentiality Agreement discussed above. [11]

Upon receipt of the data, ERG reviewed the forms for missing or incomplete information, as well as anomalous responses such as impossibly high hours per year estimates or unusual horsepower ranges for a given equipment type, contacting the survey respondents as needed for clarification through Starcrest. ERG also relied upon HCIC members for clarifications as needed. Data on each piece of equipment was then input into standardized spreadsheets for further evaluation. This data included equipment category, model year, horsepower, hours per year, and fuel use (when available), as well as the surrogate and QA data. As discussed above, ERG relied upon default values from NONROAD for horsepower and activity when data was not available, and noted the entry as such under the Remarks column. All spreadsheets are provided as attachments for the reader's review.

In order to estimate equipment populations for an entire sector based on the responses, ERG made the following assumptions. First, all equipment populations and activity reported were assumed to occur within the 8 county area. Since several respondents indicated that some fraction

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[10] Sam Wells, TNRCC Area and Mobile Emissions Assessment Section, personal communication, November, 1999.

[11] Public entities such as TXDOT and Municipalities were not coded under this procedure.

of their operations occur outside of this region, this is a conservative assumption, increasing population and activity estimates by a small, unquantified amount.

Second, subcontractors were assumed to provide 100% of their estimated activity to the general contractors identifying them. This assumption is also conservative since some fraction of subcontractor work would most likely fall under the non-surveyed portion of the sector. Therefore subsequent extrapolation to the sector as a whole will necessarily double count some portion of the equipment activity from these subcontractors.

Finally, ERG assumed that there was no significant contribution to equipment activity in the 8 county area from sources domiciled outside the region. Given the highly rural nature of most of these counties ERG believes this is a reasonable assumption.

Alternative "Top-Down" Survey Method

As the survey progressed it became apparent that response rates were too low to be useful for the Commercial and Residential Construction sectors. Therefore as an alternative approach ERG worked with the HCIC to identify local experts in each of these sectors to provide estimates of total equipment populations and activities for the 8 county area. The expert interview approach consisted of five primary steps:

- Identify alternative surrogate to assess overall activity in the 8 county area, if needed. Surrogate must be associated with model development units – see below;
- Characterize "model developments" to represent typical construction activities for each sector;
- Identify key phases of development (e.g., land clearing, utilities, paving, etc.);
- Characterize the types of equipment used in each phase, including typical horsepower and average hours of engine operation required for completion;
- Scale up to entire sector using surrogate values.

Based on these results, ERG developed spreadsheets with equipment populations and use estimates similar to those for the other sectors. The details of these analyses are presented below in the Sector Assessment section.

NONROAD and UAM Modeling

Based on the survey findings for all sectors, ERG compiled input files of engine populations and activities for use in the NONROAD model. The TNRCC ran the NONROAD model with these input files for different years to develop revised tons per day estimates for the construction sector (see Table 1 above). In addition, TNRCC staff will perform an independent QA of the data files, using data sets of equipment sales and exports for the region. TNRCC will also develop a mechanism for spatially allocating the emissions over the 8 county area, in conjunction with the HCIC, for use in future Urban Airshed Modeling exercises.

SECTOR ASSESSMENTS

The following summarizes the methodology, assumptions, and findings for each construction sector assessment.

Heavy-Highway Contractors

Surrogates for this sector were based on TXDOT project lettings within the 8 county area during FY 99 ($490M total). Lettings were assumed to vary less over time than contract awards, providing a more reliable estimate of annual activity.[12] TXDOT data indicated that two general contractors were responsible for 70.1% of all letting value for this time period. Therefore ERG limited the survey to these two contractors and their respective subcontractors, 10 of which were identified as users of heavy diesel equipment. According to survey results no subcontractor maintained any additional subcontracts with other equipment users. Therefore the survey effort for this sector was limited to these 12 companies.

The general contractor with the largest surrogate value (45.3%) also owned the largest amount of equipment, at 445 pieces. This contractor characterizes itself as a "full service provider", with a relatively low reliance on subcontractors. The other general contractor owned significantly less equipment (56 pieces), but maintained a greater number of subcontractors. Subcontractors owned much less equipment than the general contractors, averaging between 10 and 20 pieces per company. Equipment counts for surveyed sources totaled 701 pieces. Extrapolations based on surrogates estimated 1001 pieces for the entire sector. The most common equipment categories included:

- Rollers;
- Surfacing Equipment;
- Excavators;
- Cranes;
- Graders;
- Rubber Tire Loaders;
- Tractor/Loader/Backhoes; and,
- Crawler Tractor/Dozers.

The modal value for horsepower was the 100 to 175 range for most equipment categories.

Of the subcontractors identified by the general contractors, one company was deemed too small for inclusion (estimated to have 2 pieces of equipment "at most", according to the estimator for 0110). Another subcontractor, #0125, a provider of drilling services, refused to participate in the study. Therefore results from another drilling contractor (#0111) were scaled by the ratio of

[12] Bob Lanham, personal communication, January 11, 2000.

contract values as obtained from the general contractors, in order to estimate equipment types, populations, and activity levels for the non-respondent company.

Of the responding subcontractors, 4 of 9 reported having significant work in the Municipal Utility sector as well as the highway sector. Hrs/yr were allocated across these sectors based on contract values.

Specific horsepower and activity data were obtained for every piece of surveyed equipment. Electronic clock hour data served as the basis for activity estimates for general contractor 0113 and subcontractor 0118. Labor records were the basis for estimating hours of operation for general contractor 0110 and subcontractor 0129, while estimator/field operator estimates were the basis for the remainder of sources.

All but 3 of the respondents provided estimates of fuel use for the surveyed equipment. In some cases fuel usage records could not distinguish between surveyed and excluded equipment categories, and therefore overestimated fuel use per hp-hr by some unspecified amount. Gallon per hp-hr estimates ranged from approximately 0.01 to 0.044, with typical values around 0.02. This is substantially lower than the average NONROAD value of 0.055 gal/hp-hr, suggesting that the load factors assumed in NONROAD may be too high, at least for this sector.

Municipal/Utility Contractors

Surrogates for this sector were based on contract award values from a database maintained by Amtec Information Systems for calendar year 1999 (~$1.2B). This database contains a complete listing of all bids awarded by the counties and municipalities in the 8 county area.[13] Since surrogate value is based on bid awards rather than contract letting values, this measure may be subject to greater temporal variation than the highway surrogates. In addition, the evaluation period is shifted by 4 months relative to fiscal year 1999, the period used for the highway sector analysis. ERG has not applied adjustments for either of these factors. Time series evaluation of bid awards could prove very useful in determining the appropriateness of the base year choice for this sector.

The Amtec database indicates that awards have been issued to over 100 contractors during calendar year 1999. For our survey ERG identified the top 9 contractors, based on bid award values. Of these companies 6 responded to the survey. Information from 4 additional companies was available from the Highway sector surveys. These 10 companies were responsible for 15.4% of total contract awards for the area during 1999, and owned 613 pieces of equipment. Scaling this figure by the surrogate value estimates 3,885 pieces for the entire sector. Equipment types were very similar to those found in the Highway Sector, plus a significant number of “Other Equipment”. Compared to other sectors (Highway, Industrial, Rental, Municipality/County), this

[13] Jimmy Daugherty, Amtec, personal communication, March 3, 2000.

survey sampled a relatively small fraction of total activity. Therefore the sector-wide projections admittedly have a greater level of uncertainty.

Of the ten contractors surveyed, three identified subcontractors using equipment. In each case the contractor indicated that less than 10% of total contract value went to these subcontractors. Given the small size of the subcontractor contributions, ERG relied upon contractor estimates of subcontractor equipment use rather than performing full-scale surveys as was done for the Highway sector. The Municipal Contractor Spreadsheet provides the details for these subcontractor assessments, under company #0202, #0203, and #0206. In each case equipment counts total less than ten per subcontractor.

Specific horsepower data were obtained for approximately 82% of surveyed equipment, and activity estimates were obtained for over 93%, with the remainder assigned from NONROAD defaults. Activity estimates were based on a mix of clock hour data, labor records, and estimator assessments.

All but one contractor provided fuel use data. Fuel consumption rates were very similar to those observed in the Highway sector, ranging from about 0.01 to 0.04 gal/hp-hr. Average values were about 0.02 gal/hp-hr, again substantially lower than assumed in the NONROAD model.

Municipalities and Counties

This category contains equipment owned and operated by public entities in the 8 county area, including municipalities, counties, and TXDOT. TXDOT data was obtained in electronic format for all equipment domiciled in the region. Municipalities within the 8 county area were identified and ranked by 1990 census population. Due to resource constraints, only those municipalities with 1990 populations greater than 15,000 were targeted for surveys. (All 8 counties were also targeted.) A list of the targeted municipalities is provided below.

·
- Alvin
- Angleton
- Baytown
- Conroe
- Deer Park
- Friendswood
- Galveston
- Houston
- Lake Jackson
- League City
- Liberty
- Missouri city
- Pasadena
- Pearland
- Rosenberg
- Sugar Land
- Texas City

Harris County staff took the lead in identifying appropriate points of contact for each county and municipality, typically equipment managers. Of the municipalities and counties selected for surveys, all but League City and Liberty County responded for a response rate of better

than 98% on a population basis for selected entities. Surveyed equipment totaled 1,054 pieces. Equipment types were similar to those found in the Municipal Contractor sector, with the exception of cranes which were uncommon, and tractor/loader/backhoes, which were much more common.

In order to extrapolate equipment populations to municipalities and counties without survey results, ERG worked with the TNRCC to compile public works budget data for each area of interest. Ideally, this data would only include equipment related activities, excluding such budget items as design and administration. However, detailed budget breakouts were not always available for the different cities and counties. For this reason ERG relied upon aggregated public works budgets for 1999.

For areas without available budget data, budgets were estimated based on the average dollar per capita values for those areas with budget data. (See "Surrogates" page of the Municipality and County Spreadsheet for details.) Average dollar per capita values were heavily influenced by the City of Houston value ($446 per person). Therefore projections for smaller areas with missing budget data are likely overestimated.

Once public works budgets were established for the responding municipalities, adjustments were applied to account for non-respondent areas with budget data, such as League City and Liberty County. These adjustments were approximately 1% for non-respondent counties, and 5% for non-respondent cities.[14]

Additional corrections were developed to account for small municipalities not included in the original survey list and without public works budget data. Since budget data was not available for these areas, ERG had to rely on population estimates to extrapolate to the region as a whole. In the absence of other data, ERG simply subtracted the sum of the county and city population estimates for 1999, scaling surveyed equipment numbers by the ratio of surveyed to total population (scaling factor of ~42%, leading to a sector total of 1,911 pieces of equipment).

This approach is extremely conservative, assuming that construction equipment activity in the smallest rural towns and in unincorporated areas will be similar to urbanized regions on a per capita basis. Assuming a much smaller (and possibly more reasonable) scaling factor of approximately 10% lowers sector-wide equipment estimates by about 400 pieces. However, additional research is needed to determine a more accurate scaling factor for the smallest towns and unincorporated areas.

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[14] The TNRCC gathered budget data for several cities not included in ERG's survey list, including Bellaire, Humble, Kemah, Manvel, Seabrook, Stafford, Tomball and Webster. These cities are included in the non-respondent category noted above.

Horsepower and activity data were reported less consistently than for the previous two sectors. Engine specific horsepower was obtained for 50% of surveyed equipment, while activity estimates were obtained for about 63%. Note that Harris County provided neither activity nor hp data. Therefore ERG allocated reported equipment types across all hp ranges, weighted by the default NONROAD horsepower distributions. Missing horsepower data for other municipalities and counties were assumed to equal the NONROAD average value for the given equipment category. When provided, activity data was based on a number of different sources, including engine-specific fuel consumption records for the City of Houston. When unavailable, NONROAD defaults were used for activity levels.

Fuel use data were provided by roughly 50% of respondents. Values ranged from roughly 0.01 to 0.04 gal/hp-hr, as with the highway and municipal contractor sectors.

Industrial Contractors

Surrogates for this sector were based on the monthly Gulf Coast Work Force Survey conducted by the Houston Business Roundtable (HBR). This survey tracks projected man-hour requirements for construction, maintenance, and turnaround activities at the petroleum/chemical/petrochemical plants in the Houston-Galveston area. Appendix F provides a listing of the 34 facilities included in the survey.

According to HBR staff, response rates to their Gulf Coast Workforce survey typically capture about 70% of the total man-hour activity in the region.[15] ERG used this factor to scale up the total man-hour projections provided by the HBR for calendar year 1999 (47.9M worker hours per year). This surrogate could be improved in the future if projections are obtained for fiscal rather than calendar year 1999, or if actual man-hours (rather than projected hours) could be provided by the HBR or some other source. In addition, since total labor requirements can vary significantly over time depending upon the onset or completion of major projects, time series analysis of the Workforce Survey could prove very useful in determining the appropriateness of the base year choice for this sector.[16]

In order to identify key contractors for this sector, ERG consulted with ABC staff. ABC compiled a list of 11 contractors they believed accounted for at least 80% of the total man-hours for this sector.[17] Of these contractors, 5 provided information to ERG. Each Industrial respondent provided an estimate of total man-hours per year within the 8 county area. Since

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[15] Mike Rudnicki, Houston Business Roundtable, personal communication, February 16, 2000.
[16] Although month-to-month variation in the HBR projections can be as much as 25%, projections from January of 1999 through March of 2001indicate a persistent trend toward greater activity in the spring months, followed by drop-offs during the summer. Therefore the determination of appropriate base year should evaluate time series data in annual blocks or 12 month rolling windows.
[17] HCIC Industrial-Petrochemical Segment Recommendation Report, November 1, 1999.

most respondents did not differentiate between turnaround, maintenance and construction man-hours, aggregate values were used to determine activity fractions. Using the adjusted HBR estimate of total worker hours noted above, surveyed firms were responsible for 50.3% of all worker activity for this sector. No significant equipment use among subcontractors was reported by any of the respondents. (Subcontractor equipment use is reportedly restricted to welders, compressors, and other small engines <25 hp, almost exclusively.)

Equipment counts totaled 198 pieces for surveyed companies, or 396 for the sector as a whole. Equipment types were quite different from other sectors, dominated by cranes and rough terrain forklifts, along with some tractors of varying types. HCIC members independently confirmed these results, noting that this sector had very little aside from cranes and forklifts, and these were more often rented rather than owned.[18] High rental rates would help explain the low equipment ownership totals reported for this sector.

Engine-specific horsepower data was obtained for 57% of all equipment, but only 17% had activity data. Unspecified hp and activity values were assigned using NONROAD defaults. Fuel use data was sparse and unreliable on the whole.

Rental Companies

Rental companies were identified through a number of sources for inclusion in the survey effort. These sources included HCIC recommendations, survey respondents from other sectors, a Dun and Bradstreet database of construction equipment rental companies, and the 1999 Building and Construction Blue Book for Houston (perhaps the most comprehensive listing of local equipment suppliers available.) Of the 151 rental locations identified, ERG obtained survey data for 22 locations, including some of the area's largest chains.[19]

Unlike companies in the other sectors discussed above, equipment rental companies do not have a strong local trade organization. Accordingly there is no one source of data summarizing market share or total market size for this sector, such as the Amtec Municipal/Utility database or the Industrial Workforce Survey. In addition, surveyed companies were not willing to provide sales data, regardless of the availability of confidentiality agreements. Therefore ERG was forced to develop alternative surrogates for the rental sector.

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[18] Don Chaney, General Manager Wyatt Field Service Company, personal communication, December 10, 1999.

[19] Based on discussion with local sales representatives, the rental industry in Houston is currently undergoing a surge of acquisitions. For this reason much of the equipment inventory is in flux at the moment, making it difficult to survey the existing fleet. ERG believes that a significantly higher response rate can be obtained for this sector in the near future, once equipment inventories have stabilized.

Initially ERG hoped to use sales data from the Dun and Bradstreet database to determine market share for surveyed companies. However, this data relies upon voluntary reporting and lacks sales data for a large number of its entries. In addition, cross-referencing with the Blue Book indicated that dozens of companies claiming to rent construction equipment in the area were not listed in the Dun and Bradstreet data. For these reasons this data set was deemed inadequate for establishing surrogates for the rental sector.

As an alternative ERG obtained the appraised tax value for 100 rental equipment companies from the Harris County Tax Assessor's Office.[20] Specifically, companies were sorted by primary SIC code, only retaining those firms with the following codes –

- 7353 – Heavy Construction Equipment Rental
- 7359 – Equipment Rental/Leasing
- 5082 – Construction and Mining Machinery

Next, ERG consulted with AGC representatives to determine which 5082 companies actually rented equipment in volume, versus those that are primarily retail/wholesale with a small rental fleet used for promotional purposes only.[21] Companies of the later type were removed from further evaluation. Retail/wholesale companies identified as having significant rental activity had 100% of their appraised equipment value allocated to this sector to be conservative. (See the "Shop Lists" page of the Rental spreadsheet for further details.)

ERG then estimated the average appraised value of rental equipment for specific chains within Harris County, and applied these values to locations of the same chains outside the county. In addition, ERG calculated the average appraised value for single location businesses in Harris County ($1.1M, compared to $1.8M for chains), and applied this value to single location companies outside of Harris County. Based on this methodology, ERG obtained detailed survey responses from 22 locations with 1,851 pieces of equipment, representing 28.5% of total appraised value for the 8 county area. Extrapolating to the rest of the sector yields 6,536 pieces of equipment. This is the single largest sector evaluated, almost twice the size of the next largest sector, Municipal Utility Contractors.

The survey results for this sector were necessarily less detailed than those for other sectors. For example, rental companies do not track fuel use since operators are responsible for fueling on the job site. Similarly, precise location of use is not tracked carefully over time. However, in most cases activity is tracked carefully by piece of equipment, either through clock hour

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[20] Line item entries in the tax reports are not standardized, so ERG summed all entries for "Equipment", "Inventory", and "Miscellaneous" to establish the surrogates.
[21] Bob Lanham, President, AGC of Texas, Highway, Utilities, and Industrial Branch, personal communication, February 21, 2000.

data or utilization reports (e.g., "engine #1 in the field 212 days of 365"). In fact, specific activity estimates were available for about 95% of all equipment surveyed. Precise horsepower values were also provided for 95% of all equipment.

Finally, note that model year data clearly indicate that the Houston rental fleet (at least that fraction maintained by the larger locations) is relatively new, with the vast majority of engines 5 years old or newer. However, this trend may not hold for some of the smaller sites not surveyed.

The surrogate extrapolation method used for this sector admittedly contains several sources of uncertainty. The following summarizes each of these factors, and discusses the steps taken by ERG to err on the conservative (i.e., overestimate) side when possible.

Equipment valuations are missing for sites outside of Harris County -- Due to limited time, ERG was not able to obtain assessed equipment values for areas outside of Harris County, and had to rely upon the extrapolation methods described above. However we believe this approach is conservative, assuming that rental companies servicing less populated areas in the outlying counties can support the same inventory and utilization level as those companies in Harris County. This is especially conservative for highly rural counties such as Chambers, Liberty, and Waller. Nevertheless, there may be a few outlying locations supporting site-specific projects that are particularly equipment-intensive.

Some fraction of the retail/wholesale equipment fleet is neglected in the rental sector population estimates -- As discussed above, some equipment retailers/wholesalers will lease equipment on a short time frame to promote long-term sales of their products. However, according to HCIC representatives such a "demo fleet" usually consists of one or two pieces of equipment designated for this purpose, while the rest of the inventory is held exclusively for sale. Since the appraised equipment values do not distinguish between these types of equipment, it was not possible to estimate surrogates for just the rental portion of these fleets. Retaining these companies in the surrogate base would have drastically overestimated the rental fleet as a whole.[22] Therefore ERG assumed that retailers/wholesalers should be excluded from the rental sector equipment counts, unless local estimators specifically identified the company in question as a significant renter of equipment. For those retailers/wholesalers identified as such, ERG retained 100% of their appraised value in the surrogate base to be conservative. These additions totaled $6.9M, or 4.1% of the total appraised equipment value included in the surrogate base. It is likely that a significant fraction of this $6.9M inventory is actually not rented to the public, but held for public sale.

[22] For example, one Houston retailer had a rendered equipment valuation of $26M. According to HCIC representatives, this company had no significant rental fleet. Including this one location in the surrogate total would have single-handedly inflated the equipment population estimates by 13%.

Another conservative assumption in this analysis involves the inclusion of all non-Harris county companies listed in the Houston area Blue Book. The Harris County analysis found that 15 of the 100 Harris County locations identified as providers of general construction equipment rental services were actually predominantly retailers/wholesalers, according to their SIC listings. Therefore we would expect some fraction of the 51 locations outside of Harris County to actually be retailers/wholesalers as well, although the fraction may be somewhat lower for the less urbanized areas. This assumption would also tend to overestimate the equipment population available for rent in the area.

Equipment valuation estimates include ALL types of equipment, not just those targeted by the survey -- It is extremely likely that total appraised equipment values contain estimates for equipment types not evaluated in this study. Such equipment could include gasoline engines, engines less than 25 hp, on-highway trucks such as sweepers and dump trucks, "industrial-type" equipment such as regular forklifts, aerial lifts, welders, air compressors, and the like. This suspicion was confirmed by several survey respondents reporting significant amounts of equipment in these categories.[23]

As noted above the tax appraisal reports did not contain line-item information for each piece of equipment. Therefore dollar value estimates for the equipment of interest are almost certainly overestimated in this regard. However, if the respondent rental companies maintain roughly the same percentage of non-surveyed equipment types as the rest of the companies, extrapolations using inflated estimates of dollars per piece of equipment should not introduce systematic errors. The degree to which non-respondent companies also carry additional equipment types is an open question at this time.

Equipment type mix is assumed constant -- Inherent in this methodology is the assumption that all rental locations offer roughly the same equipment types, in roughly the same proportion. While we have not performed a detailed analysis of this assumption, based upon the equipment categories listed in the Blue Book the vast majority of rental companies do in fact offer a wide variety of equipment types. Product type offerings can be seen for each company on the "Shop Lists" page of the Rental spreadsheet. The most common equipment types >25 hp found in the surveys included:

- Rollers
- Excavators
- Graders

[23] In the surveys ERG requested information on all major heavy diesel equipment categories, not just those types defined as "construction equipment" in the NONROAD model. Additional equipment types included most major types of industrial equipment as well, although this information was not included in the final construction population numbers.

- Rough Terrain Forklifts
- Rubber Tire Loaders/Tractors/Dozers
- Tractor/Loader/Backhoes
- Crawler Tractor Dozers
- Skid Steer Loaders, and
- Signal Boards/Light Towers

Another indication of the variability of product offerings is the average dollar value per piece of equipment, which can be calculated for the respondent companies. These values are presented in Table 5 below. While the average value per piece of equipment does vary substantially (from about $6K to $28K), much of this variance can be explained by considering the type of equipment offered. For example, site #0010 provides a high fraction of low hp equipment, which may explain the lower dollar per piece estimates. On the other hand, the relatively high value of $28K per piece cannot be explained by the types of equipment offered – trenchers, rough terrain forklifts, backhoes, and skids. However, to the extent that the sampled rental fleet as a whole is representative of the total Houston area market, then this inter-company variation will not bias the final equipment population estimates.

Appraised values themselves are uncertain -- Only about 30% of the Harris County equipment appraisals were based on rendered data. The remainder were appraised using a number of different methods, including number of employees and/or lot size.[24] Rendered estimates were substantially higher than projections (an average of $2.1M per site for rendered data, compared to $0.7M for projections.) However, this difference may only reflect the desire of the largest companies to provide accurate data thereby minimizing their audit risk, rather than a consistent undervaluation on the part of the Tax Office. Regardless, survey responses were obtained for both rendered and un-rendered companies (7 of 16 responding Harris County locations had rendered data). Therefore extrapolations from this data set to the sector as a whole should not systematically bias the final equipment estimates in this regard.

Crane Rentals

Cranes are typically considered specialty items, and are often rented by companies dedicated to this type of equipment alone. ERG used the Construction Blue Book for Houston to identify 70 companies in the 8 county area specializing in crane rentals. ERG attempted to estimate crane rental surrogates in the same fashion as for other rentals. However, ERG did not obtain a single survey response from any of the crane rental companies contacted. For this reason, and due to the large fraction of crane rentals in other sectors, ERG recommends relying on the default NONROAD population and activity factors for the crane equipment

[24] Carolyn Mead, Harris County Tax Assessor's Office, personal communication, February 22, 2000.

category, . We believe this is a conservative assumption, considering the overestimates found in practically every other equipment category for Houston.

Residential Construction

As defined, this sector evaluated only single family construction in the 8 county area. Multi-family construction is covered under the Commercial category (see below). This sector also includes utility contract work associated with service extension up to the property line. Note that this "off-property" component includes service extensions for both residential and commercial developments – see below.

This sector features a large number of contractors and subcontractors performing very similar tasks for different developers. Given the large number of contractors involved, ERG chose to develop equipment population estimates for this sector using a "top-down" approach rather than the bottom-up survey approach used for the other sectors discussed above. Specifically, this approach relied heavily upon developers, estimators, and field managers to characterize a "model" residential development, to identify all stages of work requiring heavy equipment, and to create an equipment profile for each phase of the development. Once an equipment profile was created, including type, typical horsepower, and hours needed per phase, total equipment requirements for this sector were estimated through the use of appropriate surrogates. This process is described in more detail below.

On-Property Activities

With the assistance of HCIC members ERG identified several developers and contractors to assist with the model development characterization. Specifically, 3 local developers were consulted to define the features of a "typical" subdivision in the Houston area. Table 6 summarizes their consensus opinion for a "model" subdivision.

Table 6
Assumptions for Model Subdivision Development*

1. 100 lot subdivision
2. Lots between 50 and 80' x 120'
3. Total area -- 20 - 30 acres.
4. Forested lots assumed -- clearing required for lots and street/utility right of ways.
5. Felled trees assumed logged off site rather than pit burned -- on-highway trucks used (estimator consensus).
6. Finishing activities do not include landscaping.
7. Utility work beyond property lines not included – estimated separately.
8. 8 hrs engine operation per day, 5 days per week assumed -- estimator consensus
9. Slipform/screed paving rather than form paving assumed -- more equipment-intensive.
10. Assume backfilling on-site with cut dirt rather than hauling off-site (estimator consensus)
11. Upper end of equipment #s, activity and hp ranges selected to be conservative.

* Sources: Joe Stunja of Friendswood Development, Jim Holcomb of Holcomb/Schubert, and Wayne Myer of Coles Crossing

Table 5
Average Appraised Dollar Value per Piece of Rental Equipment

Company Code / # of Sites	Avg. Value/Shop^	Average #PCS/Shop*	Average $/PC*	Co
#0022 (11)	$2,203,369	79	$27,891	Appraised value includ shops
#0023 (3)	$3,712,340	154	$24,106	Value includes 26 on-r
#0021 (1)	$1,989,710	153	$13,005	Value includes 2 indust
#0020 (1)	$1,547,840	156	$9,922	Includes 16 forklifts, 8 plate compactors, 11 ta which <25hp. 41 pcs o assumed small.
#0011 (1)	$2,032,280	159	$12,782	Includes 13 small (<25
#0010 (1)	$517,580	92	$5,626	Approximately 1/3 of p
#0010-0011 (4)	$1,653,230	113	$14,630	# pcs based on projectio

^ From Harris County Tax Assessor; Harris County averages applied to non-Harris County locations.
* Corrected for industrial/other equipment reported but excluded from inventory.

Dallas Diesel Construction Emissions (DDCE) Project

As noted in Table 6, several conservative assumptions were made with respect to equipment usage, such as the assumption of forested lots and the use of slipform rather than form paving.

Next, each phase of the development process was identified, and contractors working in each phase were interviewed by phone to determine equipment types and hour requirements. ERG performed phone interviews with 2 Land Clearing Contractors, 3 Utility Contractors, and 4 Paving/Finishing Contractors to obtain the following information.[25] In each case ERG interviewed either the general manager or chief estimator. When discrepancies among interview results were identified, ERG contacted the other contractors to reconcile any differences as needed. The findings are summarized below in Table 7.

Table 7
Expert Equipment and Activity Characterization for Model Development

Phase	Duration	Equipment Type	#Pcs/Subdivision	HP*
Land Clearing	30 – 60 calendar days	Crawler Dozer	2	140
		Excavator	1	220
		Rubber Tire Loader	1	130
Utility Work	45 to 60 calendar days	Excavator	2	300
		Crawler Dozer	1	155
		Rubber Tire Loader	1	130
		Vibratory Compactor	1	100
Street Cutting/Dirt Moving	10 to 12 work days	Excavator	1	220
		Crawler Dozer	2	155
		Maintainer	1	140
Compaction	7 to 9 work days	Soil Stabilizer	1	300
		Maintainer	2	165
		Pneumatic Roller	1	100
		Crawler Dozer	1	80
Paving	10 to 14 calendar days	Grader	1	140
		Pavers (slipform/screeds)	2	230
		Crawler Dozer	2	80

[25] Some of the residential contractors interviewed asked for their interviews to remain confidential, so no references are provided for the data in Table 7.

		9 Wheel Roller	1	100
Finishing	7 to 10 calendar days	Crawler Tractor (3 days)	1	90
		Curbing Machine (2 days)	1	149
		Rubber Tire Loader	1	130
		Rubber Tire Roller	1	100

*From specific equipment models cited as "typical" for the given application.

By combining the activity estimates provided above with the total number of units built per year, and the default hour per year values from NONROAD, ERG derived an estimate of the total pieces of equipment for this sector. The number of lot completions were obtained from American Metro Studies for Calendar Year 1999 for most of the 8 county region (25,701). The American Metro Studies data excludes the southern half of Galveston and Brazoria Counties, as well as Chambers, Waller, and Liberty Counties.[26] H-GAC staff subsequently provided a population estimate of the 8 county area excluded under the database. Lot completions for the total 8 county area were then scaled upward based on population, resulting in a final value of 27,413 lot completions for calendar year 1999. Combining this value with the NONROAD activity estimates, ERG calculated 1,196 pieces of equipment for the on-property portion of the residential sector. We believe this figure contains significant double counting with the rental sector, however, as several HCIC members have stated their belief that the residential sector contains a very high percentage of rented/leased equipment. However, ERG did not attempt to quantify the rental fraction for this sector.

Off-Property Service Extensions

ERG contacted members of Reliant Energy's Environmental and Substation Construction Departments to obtain an estimate of service extension activities for new commercial and residential developments. ERG asked knowledgeable Reliant Staff for a qualitative estimate of market share for their key contractors. Reliant identified 4 contractors they believed were responsible for about 75% of Entex contracts, and 95% of HL&P contracts. In addition, Reliant estimated that approximately 20% of all small scale service extension work was handled internally.[27]

ERG conducted phone interviews with 3 of the 4 contractors identified by Reliant to determine equipment types and populations, as well as an estimate of their company's commitment to Entex and/or HL&P projects (i.e., their fraction of revenue from service extensions).[28] Points of contact

[26] David Jarvis, American Metro Studies, personal communication, February 17, 2000.
[27] Clem Read, Substation Construction Department, Reliant Energy, personal communication, February 15, 2000.
[28] One company did not return our calls. ERG set this company's profile equal to another company thought to be of similar size and capabilities, according to Reliant staff.

included a Vice President of Operations, a Fleet Manager, and a Field Supervisor. Although the surveys for this sector were highly qualitative, very similar equipment profiles were obtained from the three respondents, all having the following types of equipment:

- Excavators
- Backhoes
- Trenchers
- Crawler Dozers
- Bore/Drill Rigs
- Skid Steer Loaders (for two of the three respondents)

After accounting for contract value fractions and scaling up, ERG estimated that 290 pieces of equipment are involved in service extension work in the 8 county area.

For inventory purposes, default horsepower and activity values from the NONROAD model were assumed for all pieces of equipment.

Commercial Construction

This sector includes multi-family residential as well as all non-residential building construction (excluding any structures falling under the Industrial sector). This sector contains a large number of contractors and subcontractors working on a diverse set of projects. Given the large number of companies involved and a poor initial survey response rate, ERG chose to develop the inventory for this sector in a top-down fashion similar to that used for the Residential Sector.

ERG worked with HCIC members to convene a panel of experts familiar with all aspects of commercial construction in the Houston area. Table 8 lists the members of the panel convening on February 22, 2000.

Table 8
Commercial Construction Expert Panel Members

Member	Company
Pat Kiley	Executive Vice President, Houston Chapter, Associated General Contractors of Texas
Andy Richardson	Principal, Brookstone Corporation
Grant Judge	Estimator, Williams Industries
Jeff Boersteler	Vice President, Marshall Construction
Bob Lanham	Vice President, Williams Brothers Construction
Mark Self	Equipment Superintendent, WS Bellows
Amy Luskey	Director of Governmental and Community Relations, Houston Chapter, Associated General Contractors of Texas

As with the residential sector, the panel members were first asked to characterize "model developments" that could be used for extrapolation to the sector as a whole. The panel members recommended differentiating between "High-Rise" (over 4 stories) and "Low-Rise" developments, due to their different equipment requirements. Subsequently the panel identified those phases of site work that require the use of heavy equipment. Equipment estimates were based on site requirements and on total contract dollar values for the high and low-rise sectors (see below). The panel also estimated that 80 to 90% of all equipment is rented in this sector, with the exception of Bore/Drill Rigs, which are almost exclusively owned by drilling contractors. The panel's assessment of equipment types, populations and activity levels for owned equipment is provided below in Table 9.

Table 9
Expert Panel Equipment and Activity Characterization for Commercial Developments

Work Type/ Phase	Duration	Equipment Type	#Pcs Operating/Day^	Rental Fraction	HP*
High-Rise Site Work	3 months	Excavator	5	80%	203
		Crawler Dozer	5	80%	193
		Crane**	15	67%	245
Low-Rise Site Work	3 months	Crane	109	90%	245
		Crawler Dozer	109	80%	203
		Grader	109	80%	224
		Rubber Tire Loader	109	80%	211
		Excavator	109	80%	193
		Pulverizer/Mixer	109	100%	496
		Backhoe	109	80%	115
		Skid Steer Loader	109	80%	63
		Drill Rig	109	0%	257
Steel Erection	--	Crane	22	90%	245

^ 8 County Area projection
* From NONROAD defaults
** 1 Cherry picker and one crawler crane per site, 100% rental. 1 drilling crane per site, 100% owned.

High Rise Construction

High Rise construction refers to buildings greater than 4 stories in height. Health care facilities are also included in this category due to the similarity in equipment requirements. According to data obtained from CB Ellis, 4.5M square feet of high-rise office space was put in place in the Houston area in 1999. The AGC Building Development Survey for 1999 also estimated approximately 4.5M square feet of health care facilities. Based on the panel's estimate of approximately $100/square foot for high rise development, this equates to roughly $900M in total value for 1999. Assuming an average project cost of $60M per site (panel estimate), this equates to 15 projects underway at any given time during the year in the 8 county area.

Next the panel estimated total site work costs at $180M (20% of total). In addition, site work was estimated to last 3 months for a model project. Assuming a 3 month duration and 15 projects per year, site work would be ongoing at approximately 5 high rise locations at any given time. This projection was the basis for estimating the equipment needs in Table 9 above. After accounting for typical equipment utilization rates as per the NONROAD model and the likely rental fraction for each equipment type, ERG estimated the owned equipment population supporting these activities – between 2 and 3 excavators, 2-3 dozers, and about 13 drilling cranes. (Note that steel erection activities in high-rise developments utilize electric hoists almost

exclusively, and therefore were excluded. No other heavy equipment was identified for steel erection phase.)

"Low-Rise" Construction

According to Greater Houston Partnership data, Nonresidential building contract awards totaled $2.7B for calendar year 1999 for the Houston PMSA (all counties but Galveston and Brazoria). Assuming that there was no significant high-rise development in the excluded counties, the $1.8B attributable to low-rise development ($2.7 - $0.9 for high rises) was extrapolated to the full eight county area based on population ratios. Including Brazoria and Galveston County thereby increased the dollar value surrogate by about 11%, to $2.0B for the 8 county area.

The expert panel estimated that, of the 8 county low-rise total, approximately $600M was attributable to remodeling/renovation work which utilizes no heavy equipment. Therefore of the remaining $1.4B, the panel assumed an average development cost of $3M per project, yielding about 470 projects for 1999. Of these projects, site work was assumed to be ongoing for 25%, or about 120 sites at any given time. These figures were used to estimate the equipment populations listed in Table 9 above.

Concrete work was assumed to utilize just one pump truck per site, and was neglected in this analysis.

Steel erection activities only rely upon cranes, according to panel members. At approximately $90 per square foot for an average low-rise development, about $10 are dedicated to the steel erection phase (panel opinion). Of this amount, about $3 is for actual erection (versus materials), of which $1 is for equipment support/depreciation/other ownership costs. Assuming a 90% rental rate for cranes, approximately $0.10 per square foot is directly attributable to equipment ownership costs. For a model development of 35,000 square feet, with one quarter of the 470 model projects in the erection phase at any give time, this leads to only $411,000 in owned equipment costs per year for this phase. At $120 per hour for crane ownership costs,[29] ERG estimates only 2 owned cranes were dedicated to steel erection for this sector for 1999.

Multi-Family Construction

ERG obtained the permit value for multi-family construction in each of the 8 counties for 1998 from the Texas A&M University Real Estate Center database (1999 data is currently unavailable). We added this value to the low-rise dollar values to re-scale equipment populations for this sector, resulting in an increase of 9.3%.

Total Sector Populations

[29] Bob Lanham, President, AGC of Texas, Highway, Utilities, and Industrial Branch, personal communication, February 23, 2000.

Summing the high rise, low rise, and multi-family sector estimates, 940 pieces of owned equipment were projected for the Commercial sector as a whole.

Dallas Diesel Construction Emissions (DDCE) Project

FINDINGS AND RECOMMENDATIONS

Findings

Table 10 summarizes the survey results, providing the surrogates used and their data sources, the percentage coverage for respondents, and projected equipment populations for each sector. The table is ranked from highest to lowest number of equipment pieces, not by actual contributions to total emissions. For example, while the highway sector is relatively small in terms of the number of equipment pieces, this equipment typically has a much higher horsepower rating than equipment found some larger sectors, such as residential or the municipalities and counties. However, NONROAD model runs would be required for each sector to determine the specific contribution of each to total tons per day emissions levels. The rankings are provided primarily to facilitate the QA process among stakeholders familiar with the construction sector in Houston. Nevertheless, we would expect the rental and municipal contractor categories to be very important in terms of overall emissions, based solely on their large equipment populations.

Table 11 summarizes the projected equipment populations and activity levels, by equipment category, for all sectors combined. Data is sorted by the total number of equipment pieces projected by the Houston study. The table also compares these values to those from the NONROAD model for the 8 county area using default input files. This comparison allows us to identify potential anomalies in the survey projections, such as shifts in the relative importance of categories on a percentage basis, or drastically different hour per year estimates. In this way the NONROAD equipment profiles can serve as a QA tool for the survey results, assuming the NONROAD data provides a relatively accurate profile of equipment distributions (if not absolute numbers) for typical urban areas.

From Table 11 we see that the total projected population for Houston is roughly one half that projected using NONROAD defaults. With a few exceptions, each individual equipment category also had smaller populations than that predicted by the NONROAD model. In addition, for the most part equipment categories with large populations in the NONROAD model also have relatively large populations in the Houston survey. For example, the tractor/loader/backhoe category was the single largest category for both projections. However, certain equipment categories appear to be significantly different for some equipment categories. These differences are discussed briefly below.

- Excavators and Rollers have relatively higher populations in the Houston survey than in the NONROAD model. Some of this increase may be due to double counting of rental equipment in the residential sector, although equipment counts are likely to remain high even after a correction;
- Cranes make up a significantly greater percentage of the total population in the Houston survey. However, this is most likely an artifact of relying on the NONROAD defaults for this category, which appear to be systematically higher in terms of absolute equipment numbers.

It is likely that additional survey results for cranes would find a lower total population, thereby minimizing percentage differences with NONROAD projections;

- The percentage of Skid Steer Loaders, Rubber Tire Loaders, and Off-Highway Tractors in the Houston Survey are all lower than that predicted by NONROAD. However, it is likely that some fraction of these equipment types were assigned to the Tractor/Loader/Backhoe or the Crawler Tractor/Dozer categories, depending upon the availability of make/model data and ERG's "assignment rules", as discussed in Appendix B. Such assignments would tend to inflate the relative differences between these categories somewhat;
- Bore/Drill rigs are higher in the Houston survey, although the difference is small in absolute terms (about 400 pcs);
- Surfacing equipment in the Houston survey is significantly higher than in the NONROAD model, due to the assignment of all crushing/processing equipment to this category, along with some amount of miscellaneous paving equipment, which tends to explain the low percentages seen for paving equipment as well;
- Rough terrain forklifts and trenchers have a lower percentage population in the Houston Survey than in the NONROAD model;
- Scrapers and off-highway tractors are all significantly lower in percentage terms in the Houston survey than in the NONROAD model. However, according to HCIC members, these equipment types are predominantly used in rural areas and are seldom found in the Houston area;[30]
- Off Highway Trucks are highly specialized pieces of equipment that also find little application in the Houston region, according to HCIC members, explaining their extremely low population estimates in the Houston survey.[31]

Although some discrepancies do exist between the NONROAD and Houston survey equipment profiles, much of the differences have relatively little impact on final emissions estimates. Table 12 provides the estimated horsepower-hours, by category, for NONROAD and the Houston survey. HP-HR is very closely correlated to total emissions rates, and serves as an adequate measure of the relative impact on emissions from the different equipment types. From the table we see that several of the equipment categories with relatively low average hp ratings are now quite similar, in terms of hp-hr contributions. Specifically, the roller, skid steer loader, rubber tire loader, rough terrain forklift, trencher, and paving equipment categories are all now within 1 to 2% of each other, thereby minimizing concerns over any discrepancies in the population estimates. Therefore in ERG's assessment the only equipment categories with significant unexplained differences at this time include the excavators, and possibly the bore/drill rigs.

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[30] Bob Lanham, President, AGC of Texas, Highway, Utilities, and Industrial Branch, personal communication, March 13, 2000.
[31] Ibid.

Table 10
Summary of Survey Results, by Sector

Rank (by # pcs)	Sector	Surrogate(s)	Data Source	Percentage Surveyed	Projected Population*	% of Total Population
1	Rental	Tax Role Appraised Value	Harris County Tax Assessor	28.5%	6,536	37.8%
2	Municipal Contractor	1999 calendar year Contract Awards	Amtec Information Systems	15.4%	3,670	21.2%
3	Municipalities/Counties	1999 calendar year Population/Public Works Budgets	Census/Public Works Depts	55.2% (population basis)	1,884	10.9%
4	Cranes	1996 Sales Data	NONROAD model	--	1,619	9.4%
5	Residential^	1999 calendar year lot completions	Adjusted American Metro Studies Database	--	1,486	8.6%
6	Highway	FY 99 lettings by county	TXDOT	70.1%	945	5.5%
7	Commercial	1999 calendar year Non-residential and 1998 Multi-family awarded contract values	Greater Houston Partnership / Texas A&M Real Estate Center	--	895	5.2%
8	Industrial	1999 calendar year Man-hour projections	Houston Business Roundtable Gulf Coast Workforce Survey	50.3%	268	1.5%

* Crane counts removed from sector projections.
Total 17,292
^ Includes significant but unquantified double counting with rental sector.

Table 11
Population and Activity Estimates by Equipment Type

Equipment Type	Population				Activity (Hrs/Yr)	
	Houston Study		NONROAD		Houston Study	NONROAD
	#	%	#	%		
Tractors/Loaders/Backhoes	3,225	18.7%	5,562	18.9%	765	1,135
Excavators	2,335	13.5%	1,809	6.1%	764	859
Crawler Tractor/Dozers	2,128	12.3%	3,743	12.7%	819	936
Rollers	1,651	9.5%	1,612	5.5%	549	745
Cranes*	1,619	9.4%	1,619	5.5%	806	806
Skid Steer Loaders	1,445	8.4%	4,096	13.9%	844	818
Rubber Tire Loaders	1,224	7.1%	3,474	11.8%	858	761
Graders	708	4.1%	1,375	4.7%	717	821
Bore/Drill Rigs	642	3.7%	270	0.9%	513	466
Surfacing Equipment	489	2.8%	68	0.2%	573	561
Rough Terrain Forklifts	472	2.7%	1,325	4.5%	1,041	662
Other Construction Equipment	350	2.0%	153	0.5%	516	606
Trenchers	242	1.4%	1,373	4.7%	601	593
Pavers	194	1.1%	495	1.7%	709	821
Signal Boards/Light Towers	157	0.9%	71	0.2%	528	535
Rubber Tire Tractor/Dozers	112	0.6%	91	0.3%	466	899
Concrete / Industrial Saws	106	0.6%	35	0.1%	508	580
Paving Equipment	90	0.5%	674	2.3%	344	622
Off Highway Trucks	57	0.3%	398	1.4%	1,257	1,641
Scrapers	37	0.2%	566	1.9%	455	914
Off Highway Tractors	9	0.1%	525	1.8%	853	855
Crushing/Processing Eqpmt**	0	0.0%	146	0.5%	0	955
TOTAL	**17,292**		**29,480**			

* ERG adopted NONROAD default values for cranes.
** ERG assigned all crushing/processing equipment to Surfacing Equipment and Other Equipment.

Table 12
Relative HP-HR Contributions by Equipment Type

Equipment Type	Avg HP*	% Contribution to Total HP-HR	
		Houston Study	NONROAD
Tractors/Loaders/Backhoes	115	12.5%	16.0%
Excavators	193	15.1%	6.6%
Crawler Tractor/Dozers	203	15.5%	15.6%
Rollers	128	5.1%	3.4%
Cranes	245	14.0%	7.0%
Skid Steer Loaders	63	3.4%	4.6%
Rubber Tire Loaders	211	9.7%	12.3%
Graders	224	5.0%	5.6%
Bore/Drill Rigs	257	3.7%	0.7%
Surfacing Equipment	496	6.1%	0.4%
Rough Terrain Forklifts	127	2.7%	2.5%
Other Construction Equipment	190	1.5%	0.4%
Trenchers	85	0.5%	1.5%
Pavers	121	0.7%	1.1%
Signal Boards/Light Towers	22	0.1%	0.0%
Rubber Tire Tractor/Dozers	479	1.1%	0.9%
Concrete / Industrial Saws	80	0.2%	0.0%
Paving Equipment	142	0.2%	1.3%
Off Highway Trucks	755	2.4%	10.8%
Scrapers	440	0.3%	5.0%
Off Highway Tractors	394	0.1%	3.9%
Crushing/Processing Eqpmt	112	0.0%	0.3%

* From NONROAD defaults

Recommendations

Dallas Diesel Construction Emissions (DDCE) Project

Appendix A
Background Documentation on Current Off-Road Inventory

KEY ASSUMPTIONS FOR NONROAD NOx INVENTORY DEVELOPMENT

Radian International, in conjunction with the TNRCC, has developed a list of the key assumptions and methods used to develop the base and future year NOx emissions inventories for construction and commercial marine sources operating in the Houston ozone non-attainment area. The methods used to spatially and temporally allocate these emissions for UAM applications were also determined. Each of these assumptions and calculation procedures may impact the attainment demonstration effort currently underway.

The following summary may allow interested parties to identify means of improving the current EI and/or UAM inputs for these source categories. Potential modifications to the current EI/UAM files should be prioritized according to the length of time required to gather and QA data and supporting documentation. Specifically, peer reviewers should distinguish between modifications that can be accomplished in a one to two week time frame, and those that can be completed over a six to eight month period.

Given the short time period available for the first round of analyses, the TNRCC requests that reviewers provide their recommendations by close of business, Wednesday June 2. Comments should be sent to Rick Baker of Radian International, either by fax (512-419-5566), or e-mail (rick_baker@radian.com). Rick can be reached at 512-419-6041 if there are questions regarding the peer review process.

Construction Sources

Base Year Inventory: The original base year for the construction source inventory is 1990. Values for this inventory were compiled from a standard look-up table, from EPA's Nonroad Engine and Vehicle Emission Study (NEVES) of 1991. The NEVES was developed from the Power Systems Research (PSR) national database of engine sales and populations, as well as from confidential manufacturer reports. The key parameters used to calculate NOx emissions for each equipment type included:

- equipment population;
- average horsepower rating;
- average engine load factor;
- annual hours of operation; and,
- emission factors.

Dallas Diesel Construction Emissions (DDCE) Project

EPA estimated county level equipment population values by allocating the national level data using construction activity surrogates from the Census Bureau's County Business Patterns Report of 1991. EPA currently believes this allocation scheme can be improved, and uses "dollar value of construction" estimates from the F.W. Dodge database in the NONROAD emission factor model currently under development.[32]

While equipment population numbers were estimated specifically for the Houston area, the remainder of the calculation parameters were assumed constant for all areas of the country. Seasonal adjustments were applied to the different equipment types to estimate average emissions per ozone summer day – see "Spatial/Temporal Allocations" below for a discussion.

The NEVES inventory developed two distinct sets of emissions estimates, termed Inventories A and B, using different data sources. Inventory A relied upon publicly available data sources (primarily the PSR database), while Inventory B utilized survey results from manufacturers (primarily the Equipment Manufacturer's Institute – EMI – for construction equipment). As per EPA guidance, the TNRCC used the arithmetic average of these inventories for the Houston base year estimates. However, comparison of the A and B inventories reveals large discrepancies in national population estimates for certain key equipment types, including:

- concrete/industrial saws – 37,035 vs. 98,236;
- rough terrain forklifts – 56,070 vs. 27,349;
- rubber tire loaders – 212,887 vs. 130,000;
- tractors/loaders/backhoes – 300,630 vs. 189,000;
- crawler tractors – 285,923 vs. 159,000.

There were significant differences in average load and annual use estimates for many of these equipment types as well. Therefore the use of an average value between "A" and "B" may introduce significant error into the calculations.

Other equipment classes had fairly similar parameter estimates between the two inventories, providing increased confidence in their accuracy, considering the independence of the data sources. In addition, for uncontrolled construction sources NEVES provides emission rate estimates for both new and in-use NOx emissions – however, NOx emissions typically increase relatively little over the life of an engine, especially for diesel engines. Therefore there is only a small difference between new and in-use NOx factors found in NEVES, for all equipment types.

(Note: A recent study conducted by the TNRCC generated site-specific construction activity data for a certain portion of the Port of Houston. Survey response for this effort was over 90%,

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[32] The NONROAD model is not officially approved for SIP development purposes at this time. However, its approval is anticipated later this year.

leading to a high degree of confidence in the results.[33] While these sources represent only a small fraction of the total activity in the area, some interested parties believe this data may be used to extrapolate certain types of equipment activity beyond the Port. This remains an open question.)

Growth Factors: The TNRCC estimated 1993 emissions for nonroad sources, including construction equipment, by applying standard growth factors from the Department of Commerce's Bureau of Economic Analysis (BEA) to the 1990 base year inventory from NEVES. The BEA economic indicators used surrogates for emissions growth, including number of employees, earnings, and gross production for different economic sectors, including construction. In addition, these indicators are fairly aggregated – for instance, the surrogates provided for Texas include only 4 regions.

Given the lack of regional specificity of these factors, TNRCC subsequently contracted with REMI to revise the BEA growth factor model to include 31 distinct regions for the state. However, it is Radian's understanding that in developing the current nonroad inventory for 2007, TNRCC staff used a set of growth factors from EPA's new NONROAD model applied to the baseline 1993 EI.[34] For this model EPA performed a time series analysis of the construction equipment population estimates found in the PSR PartsLink database. While it is unclear from the EPA documentation if these trends are estimated at the state or national level, EPA considers these growth factors to be superior to those provided by the BEA. Unlike the BEA data, the PSR factors also account for influences such as fuel switching and labor substitution within a sector.

A comparison of the two data sources found the PSR estimates to be significantly higher than the growth factors from BEA over the 1990 to 1996 period. These factors are summarized below for construction sources:

Projected Average Annual Growth Rates for Construction Equipment (from NONROAD Report NR-008, 1998)

BEA	PSR Diesel	PSR Gasoline	PSR Total
1.0%	3.6%	0.3%	2.6%

TNRCC also used data from the NONROAD model to account for the effect of equipment scrappage and technology turnover as a result of new federal emission standards. These elements tended to reduce overall emissions growth to about 1% per year or less. Therefore TNRCC's final projected inventory for 2007 increased very little compared to the base year EI. (At this time neither Radian nor TNRCC was able to determine the precise effect of each of these competing

[33] Additional survey work was performed by Environ for road, residential and commercial construction activity, but response rates were too low to be useful.
[34] The TNRCC used the REMI model for other source categories, including marine sources.

factors – they are "embedded" in the NONROAD model and require additional research for clarification.)

Temporal Allocations: In order to perform UAM modeling runs it is necessary to allocate the total annual emissions estimates from NEVES (or other sources) to account for seasonal, weekly, and diurnal variations. For southern regions such as Houston, NEVES and the current NONROAD model both assume 33% of construction activity occurs between June and August, 20% from December through February, with the remainder distributed evenly across the spring and fall months. These adjustment factors were developed in a 1973 study conducted by Southwest Research Institute, which was not available at the time of this writing. Therefore we do not know the ultimate basis for these estimates.

However, TNRCC and Radian have identified a potential discrepancy between the EI development process and the UAM file preparation tasks, involving the use of seasonal adjustment factors. Specifically, given the above factors, the EI was not corrected for the modeling scenarios occurring in September and October – it was assumed that all daily EI values could be used without adjustment for all months. The TNRCC modeling staff has agreed to investigate the effects of applying the necessary adjustments (i.e., applying a factor of 0.078/0.11 to the September and October modeling runs).

The NEVES study did not provide weekly adjustment factors for the EI. However, the TNRCC attempted to account for decreased construction activity on the weekends. Specifically, TNRCC estimated a 30% decrease in construction activity (and therefore emissions) on Saturdays, and a 60% decrease on Sundays, based on general familiarity with business activities in the state. (Similarly, the NONROAD model assumes a 50% reduction in activity for both weekend days – the basis of this assumption is uncertain, however). Depending upon the availability of reliable information, these factors could be modified relatively easily.

Neither the NEVES nor the NONROAD estimates provide daily adjustment factors. TNRCC relied upon default diurnal adjustment factors from the UAM preprocessing system, EPS-2, to allocate daily emissions on an hourly basis. This allocation assumes a "step function", where emissions are a factor of 4 higher between 7 a.m. and 6 p.m., compared to nighttime emission rates. Emissions are evenly allocated within these 12 hour blocks. Radian has not been able to determine the basis for the EPS-2 adjustments as of this time.

Spatial Allocations: County-level EI estimates were allocated across 4x4 km grid cells for UAM modeling. The TNRCC relied upon spatial surrogates developed by SAI in 1995 to allocate construction emissions. These were areal surrogates, termed "Commercial/Residential/ Industrial", and were based on USGS Land Use/Land Cover data, dating back to the early 1990s. TNRCC staff have speculated that the areal distribution of construction activity may have shifted significantly outward from downtown Houston during the last several years, and request additional sources of information that would justify such a redistribution of emissions.

Appendix B
PSR Equipment Category Descriptions and Assignment Rules

- pavers
- tampers/rammers
- plate compactors
- concrete pavers
- rollers
  - landfill compactors
  - static and vibratory rollers
- scrapers
- paving equipment
  - concrete finishers
  - concrete vibrators
  - other miscellaneous paving equipment
- surfacing equipment
  - asphalt/gravel planers
  - asphalt mixers/agitators
  - crack/joint routers
  - pumer kettles/melters
  - soil stabilizers
  - road reclaimers
  - pavement profilers
  - roofing equipment
  - other misc/surfacing equipment
- signal boards
- trenchers
  - portable/walk-behind trenchers
  - riding trenchers
  - cable layers
  - wheel trenchers
- bore/drill rigs
  - horizontal boring machines
  - self propelled drills
  - truck-mounted drills
- excavators
  - dragline excavators
  - hydraulic excavators
- concrete/industrial saws
- cement and mortar mixers
- cranes
  - pedestal cranes
  - rough terrain cranes
  - shovel-type cranes
  - straddle cranes
  - truck mounted cranes
- graders
- off-highway trucks
- crushing/processing equipment
- rough terrain forklifts
- rubber tired loaders
- rubber tired dozers
- tractors/loaders/backhoes
- crawler tractors
- skid steer loaders
- off-highway tractors
- dumpers/tenders
- other construction equipment
  - concrete pumps
  - other miscellaenous construction equipment
    - concrete breakers
    - rod benders/cutters
    - highway repair equipment

Equipment Category Assignment Rules

The following summarizes the convention adopted by ERG to assign certain pieces of equipment to specific NONROAD engine classifications. ERG relied upon the NONROAD horsepower distributions within a category for guidance in establishing these rules. For example, "off-highway tractors" were relatively few in number, with very high horsepower ratings (typically >300 hp). Therefore most "tractors" were assigned to other tractor-type categories, unless a very high hp was indicated.

- If a piece of equipment simply designated as a "tractor" was < 75 hp, it was assigned to the TRACTOR/LOADER/BACKHOE category;
- If "tractor" >75 hp, assigned to CRAWLER TRACTOR/DOZER;
- If "off-highway tractor" < 100hp, it is assigned to the TRACTOR/ LOADER/BACKHOE category, otherwise it was assigned to the OFF-HIGHWAY TRACTOR category.
- If a "mower" was attached to a tractor, agricultural/landscaping applications were assumed and the item was deleted from the data set;
- According to NONROAD, all "PLATE COMPACTORS" are <25 hp, and are therefore excluded from the study. When plate compactors >25 hp were reported, they were assigned to the ROLLER category;
- "Spreaders", "Soil Stabilizers", and "Rotomills" were assigned to SURFACING EQUIPMENT;
- "Hammers" were assigned to OTHER CONSTRUCTION EQUIPMENT;
- SIGNAL BOARDS as listed in the spreadsheets include light towers;
- All "CRUSHING/PROCESSING EQUIPMENT" was re-assigned to SURFACING EQUIPMENT, due to an ERG oversight;
- All "off-highway trucks" registered for on-road use, including all municipal dump trucks, were removed from the inventory;
- The following equipment categories found no engines >25 hp, and were therefore excluded –—tampers/rammers, mixers, dumpers/tenders;
- The following equipment types fell under Industrial or other NONROAD equipment categories and were excluded – mowers, regular forklifts, sweepers, air compressors, aerial lifts.

Appendix C
Houston Construction Industry Coalition
Recommended Approach to Equipment Inventory
December 10, 1999

The Houston Construction Industry Coalition (HCIC) was organized to develop and recommend an approach for developing an emissions inventory of specified diesel-powered equipment used by the construction industry. A key factor in successfully developing the emissions inventory will be an understanding of the types, numbers, and usage patterns of the construction equipment. This document describes the HCIC's recommended approach for gaining that understanding through a process that includes interviewing knowledgeable industry personnel.

Category Definitions

The members of the coalition have agreed upon a logical segmentation of the construction industry into five categories, listed below with their primary focus of activity.

- Residential (single family)
- Commercial (commercial, office, light industrial, high-rise, multi-family residential, etc.)
- Industrial/Petrochemical (chem/petrochem plant construction & maintenance)
- Municipal/Utilities (water/wastewater, other infrastructure)
- Highway/ Heavy Civil (highways, bridges, etc.)

The five categories were chosen after consideration of the types of activities that characterize construction work in general, and the potential methods of tracking future growth in the construction industry.

The first three categories (residential, commercial, and industrial/petrochemical) share many operational similarities. For example, most use of diesel equipment in each category occurs in the initial stages of the project, which include site preparation, installation of underground utilities, and installation of concrete slabs and foundations. Once the project reaches the structural erection stage, most heavy equipment is no longer needed, and power can be provided by commercial electricity, which is generally available by this stage of the project. (A notable exception is the use of cranes, which may occur in the later stages of construction.) Additionally, there is little ownership of construction equipment by companies in these categories, because of the high cost of purchasing and maintaining such equipment and the frequent need for different types of equipment for specific jobs. It is more cost-effective for companies working in these categories to rent the specific piece of equipment they need for a job rather than purchase many different types of equipment that may or may not be appropriate for any given project. Despite these similarities, the categories have been defined separately because of important differences, such as the types of structures or facilities constructed and the methods available to track market changes and forecast future growth. Each of the first three categories includes the following activity stages:

- Site preparation such as land clearing, leveling, and filling.

- Installation of roads and underground utilities by the contractor for a specific building or development (roads and utilities installed by a city, county, or state will be covered under the municipal/utility category);

- Excavation, preparation, pouring, and finishing of concrete slabs or foundations;

- Erection and finishing of structures and buildings.

The five categories are described in detail below, including reference to applicable codes under the Standard Industrial Classification (SIC) and North American Industry Classification System (NAICS) classification systems.

Residential Category – This category includes developers and builders of primarily single-family homes but also of dwelling units up to four families. This is mainly the category encompassed by SIC code 1521 – General Contractors-Single Family Houses, and also includes a portion of 1531 – Operative Builders, as it relates to builders of single-family houses. Builders of multi-family dwellings (apartments, hotels, etc., SIC code 1522) are included in the "commercial" category because the activities and building types have more in common with those of commercial builders than with residential developers or builders.

This category involves a relatively large number of developers and contractors. It may be possible to limit the number of interviews if a consistent pattern of equipment use is indicated among the contractors contacted (with respect to activities and rental *vs* ownership.) A survey of contractors working in this category has been initiated to establish their relative size rankings based on the amount of land developed by each contractor. This information may also be important in making projections of future emissions.

Commercial Category – This category includes builders of any of a wide range of structure types including office buildings, shopping malls, apartment complexes, light industrial facilities, and warehouses. This is mainly the category encompassed by SIC codes 1541 – General Contractors-Industrial Buildings and Warehouses, 1542 – General Contractors-Nonresidential Buildings, Other Than Industrial Buildings and Warehouses, and 1522 – General Contractors-Residential Buildings, Other Than Single Family. Also included are portions of 1531 – Operative Builders, as it relates to builders of multifamily housing and manufacturing, light industrial, commercial, and institutional buildings.

Activities in this category that involve the use of equipment subject to this study are conducted by contractors working in three subcategories:

- Dirt work/site preparation (including demolition of pre-existing structures).
- Concrete work.
- Steel erection.

A survey has been initiated to determine the prevalence of equipment rental *vs* ownership in these subcategories.

Industrial/Petrochemical Category – This category includes companies that build or maintain industrial complexes such as petroleum refineries and chemical plants. This includes many of the activities included in SIC code 1629 – Heavy Construction, NEC, although the new NAICS more closely describes this category in group 23493 – Industrial Nonbuilding Structure Construction.

Municipal/Utility Category – This category includes companies or government entities that install or maintain infrastructure such as water and sewer lines, pipe lines, power and communication lines, and local roads and streets. In addition, this category includes companies or government entities that conduct projects that involve large-scale earth-moving equipment such as drainage and flood control projects, construction of water and wastewater treatment plants, and development of athletic fields, golf courses, and parks. This category includes the activities included in SIC code 1623 – Water, Sewer, Pipeline, and Communications and Power Line Construction. In addition, this category includes most of NAICS group

23499 – Nonbuilding Structures Except Industrial Construction. (This NAICS group also includes equipment rental companies that provide construction equipment with an operator.)
The municipal/utility category is typically more equipment-intensive than the preceding three categories, and construction equipment is often used throughout the course of a project. In addition, there is more ownership and less rental of equipment in this category.

Highway/Heavy Civil Category – This category includes companies that build and maintain highways and bridges. This category is encompassed by SIC codes 1611 – Highway and Street Construction, Except Elevated Highways, and 1622 – Bridge, Tunnel, and Elevated Highway Construction. This category also includes, in limited amounts, activities included in SIC code 1623 – Water, Sewer, Pipeline, and Communications and Power Line Construction and 1629 – Heavy Construction, Not Elsewhere Classified.

Like the municipal/utility category, this category is characterized by the use of construction equipment throughout the duration of a project. The work elements for this category are quite similar to those for the municipal/utility category except that they are much larger in scale.

Typical elements of work covered in the highway/heavy civil category include, but are not limited to:

- Large scale earthmoving and grading.
- Drainage pipes and culverts.
- Flood detention.
- Utility installation/relocation.
- Road sub-bases.
- Paving of all types.
- Bridge foundations.
- Bridge substructure.
- Bridge superstructure.
- Miscellaneous appurtenances.

Large regional or national companies that own much or all of their equipment and rent only under special circumstances typically conduct this type of work in the Houston area.

The building of roads in support of construction projects in the other categories will typically be addressed with the road-building subcontractors in each category.

SIC Code Review

The five construction industry categories have been described above in terms of the SIC codes applicable to the types of work being performed. This can be used to help ensure that the study covers the areas of construction work that involve the use of diesel construction equipment. A list of SIC codes in the construction groups (groups 15 – General Building Contractors, 16 – Heavy Construction Contractors, and 17 – Special Trades Contractors) has been included as Attachment 1. This list is subdivided by 4-digit SIC code and includes the 5-digit NAICS codes for subdivisions of the 4-digit SIC code. The list is also labeled to indicate how the construction industry categories defined above relate to these codes.

Most of the construction activities that make use of diesel construction equipment are covered by SIC major groups 15 and 16. However, the following activities in major group 17 also involve the use of diesel construction equipment:

- 1771 – Concrete Work
- 1781 – Water Well Drilling
- 1791 – Structural Steel Erection
- 1794 – Excavation Work
- 1795 – Wrecking and Demolition Work.

Because this work is performed in conjunction with projects falling into one of the five categories, these activities will be captured during the study by interviews and surveys of subcontractors and rental equipment suppliers. The remaining activities within major group 17 do not involve the use of diesel construction equipment as defined for this study.

Contractor/Subcontractor Approach

The approach recommended by the HCIC is to work with a limited number of companies that represent a large share of the work in each particular industry category. Information should be obtained from these companies by a combination of interviews with knowledgeable personnel and requests for data in electronic or hardcopy (paper) form. An initial list of contractors identified by the HCIC for inclusion in this process is presented in Attachment B. Additional contractors and contacts will be identified during the interview process. Because developers and general contractors use a number of subcontractors to perform specialty work and to meet goals for utilization of historically under-utilized businesses (HUBs), major subcontractors working in each industry category should also be contacted. Attachment B includes an initial list of subcontractors.

Focusing on the companies with the largest share of the market in this area will provide a large amount of representative information while limiting the expense and time requirements of contacting a greater number of companies. For example, two contractors working in the highway/heavy civil category together account for over 70% of the awarded contract values in the Houston area. For the industrial/petrochemical category, eight general contractors have been identified that together represent a large proportion of the market, and a similar number has been identified for the municipal/utility category. For the residential construction category, information will need to be collected from a larger number of developers and contractors than in the industrial, highway, or municipal categories.

Note for the industrial category: Although we have not yet identified an effective means of determining market share or the size of the market for this category, there is a method with potential that has been identified. A potential indicator of construction activity in the industrial category is the use of "manpower" records and projections prepared by the Houston Business Roundtable (HBR), an association including many owners of chemical/petrochemical plants in the area. These records show the worker-days needed in this industry category on a month-by-month basis, and indicate the levels for both maintenance and turnaround activity.

A preliminary review shows that worker demand during turnarounds, when major construction projects at existing facilities are generally undertaken, is higher during fall and winter months than in summer. This is consistent with general industry knowledge that turnarounds are scheduled for months when fewer people are on vacation and demand for gasoline is lower. (Refineries must cut back or halt gasoline production during turnarounds, which they do not want to do when gasoline demand and price are high.)

The use of HBR worker demand data as a surrogate determining industry activity and to assist in temporal allocation of emissions is being evaluated further, although finalizing this issue should not impede the implementation of other aspects of these recommendations.

The interviews will be used to determine the types of equipment used during projects performed in each category, patterns of use and ownership of the equipment, and the availability of records that may provide detailed information on such factors as equipment usage and age. The amount of electronically stored information on equipment or equipment usage and subcontractors may be low for many contractors. Data collection methods may need to be tailored to each company to ensure adequate data collection.

Rental Equipment Approach

Contractors operating in the residential, commercial, and industrial/petrochemical categories make extensive use of rented equipment. Because of this widespread use of rental equipment the HCIC recommends that information on equipment use in these categories be obtained primarily from the companies that rent the equipment to contractors and subcontractors. The following paragraphs provide more detail on the HCIC's proposed approach for the residential, commercial, and industrial/petrochemical segments of the construction industry.

First, the contractors and subcontractors identified for each industry category should be interviewed to determine the relative proportions of each equipment type that are owned versus rented by the contractors and subcontractors. This will verify the underlying assumption and, if necessary, will provide a ratio for extrapolating rental companies' equipment use data to the fraction of the equipment that is contractor-owned.

During these interviews, the contractors and subcontractors should be surveyed to determine patterns of use of the individual types of equipment. This will provide a basis for apportioning the rental companies' equipment use data among the four construction categories for which this approach is recommended, if patterns of use are not consistent among the four groups. For example, a type of equipment may be used extensively in commercial construction projects but little in residential construction. Documenting these differences, if they exist, will help in the spatial allocation of emissions for modeling purposes.

Information on equipment that should be sought from rental companies includes makes and model numbers to assist in determining operating characteristics, rental periods, locations of use, and operating hours while rented. Since the amount of information that companies collect and maintain will vary, not all of this information will be available from all rental companies. However, enough information should be available to permit extrapolation to the rental market as a whole, and from the rental market to the owner-operated fraction for each equipment type and each industry category.

Information on the rental companies can be obtained from Dun and Bradstreet, who provide information based on SIC code (equipment rental companies are classified under SIC code 7353). The information available includes contact name, phone number, and address, as well as each company's number of employees and sales (dollars). This information can be used to extrapolate from the surveyed companies to the rental market as a whole. The table below contains an initial list of rental companies. This list should be compared with the Dun and Bradstreet information after it is obtained. A Dun and Bradstreet representative (Ivan) can be reached at 800-624-5669, ext. 6434.

<u>Initial List of Equipment Rental Companies</u>

General Rentals:	**Contact**	**Telephone No.**
Gaedcke/United Rentals	Terry Barbeau	713-674-4040
Mustang Industrial Equipment	Joe Trapani	713-675-1552

Rental Service Corporation	Jay Queen	281-428-1688
Prime Equipment	Bob Hodson	713-468-8363
Neff Equipment	Paul Gray	713-650-3295
Nations Rent	Dick Schock	713-477-7368
Hertz Equipment	Kyle Foley	281-364-5100
Lone Star Equipment		713-697-3287
Dunn Equipment		281-470-2387
Rush		
Pinnacle		
Industrial Air Tools		
Air Tool Exchange		
Crane Rentals:		
Anthony Crane	Andy Grant	281-471-1763
Turner Bros.	John Turner	281-456-0101
Riggers and Erectors	Charles Fayle	281-843-3142
Joe D. Hughes		
McRay Crane & Rigging		
TNT Crane & Rigging		
Phillips Crane & Rigging		
E.L. Lester & Company		

Confidentiality

An important issue that needs to be addressed is the confidentiality of information obtained from the rental companies and from the contractors and subcontractors. Rental companies, contractors, and subcontractors will be requested to provide printed information (i.e., computer print-outs, copies, summaries, etc.) without company identification as much as feasible. This printed information will go first to Starcrest who will remove identifying information and add a company-specific code. The information will then be passed on to ERG. After the conclusion of the project ERG will return the material, including any copies made, to Starcrest for disposal. No copies of information provided by rental or contractor companies are to be retained by ERG. Companies providing the information will be advised to retain copies of submitted information for their records. Information that is considered to be public, such as information relating to contracts awarded by the Texas Department of Transportation, may be transmitted directly to ERG at the information provider's discretion.

In addition to the procedure described above, the HCIC will provide bound notebooks for ERG field data collection personnel for taking notes during interviews. The notebooks will remain the property of the HCIC (specifically, of the coalition member association providing the notebooks) and will be returned to Starcrest on behalf of the HCIC at the conclusion of the project.

The information on equipment rentals does not need to be tied to particular construction companies because we are interested in market-wide rental and use patterns and not in specific companies. However, it will be important to clear the collection and use of this data with the construction companies involved because identifying information may be closely linked to the usage data in the rental companies' records.

There are four scenarios by which information may be obtained from the rental companies, contractors, and subcontractors.

- The information may be provided verbally during an interview and written by the field data collector in the HCIC-provided notebook.

- The company being interviewed may be able to provide anonymous summaries from their records that would not reveal the company's name or the names of other companies renting equipment. This information would still be provided first to Starcrest for transfer to ERG.

- The company being interviewed may be able to provide copies of company-specific records to Starcrest for transfer to ERG after identifying information has been removed.

- Records may need to be reviewed in the company's office, in which case Starcrest would assist in developing a coding scheme that would allow the ERG data collector to record information in the HCIC-provided notebook without making reference to specific companies.

As an additional confidentiality safeguard, ERG will develop a standard confidentiality statement to be provided to each company being interviewed.

Equipment Inventory

A specified list of equipment is under consideration for this emissions inventory. This equipment is listed below.

It should be noted that the definitions of equipment types as listed by Source Classification Code (SCC) number have not been available to the coalition, and the meaning of some of the terms is not clear based on common construction industry terminology. Therefore, the use of each equipment type should be confirmed during the data collection phase. It is likely, however, that most, if not all, of the equipment listed is used at least occasionally during construction projects in all categories, although not extensively in all categories and not on all projects.

List of Construction Equipment to be Included in Study

SCC	Diesel Equipment
2270002003	Pavers
2270002006	Tampers/Rammers
2270002009	Plate Compactors
2270002012	Concrete Pavers
2270002015	Rollers
2270002018	Scrapers
2270002021	Paving Equipment
2270002024	Surfacing Equipment
2270002027	Signal Boards
2270002030	Trenchers
2270002033	Bore/Drill Rigs
2270002036	Excavators
2270002039	Concrete/Industrial Saws
2270002042	Cement & Mortar Mixers
2270002045	Cranes
2270002048	Graders
2270002051	Off-highway Trucks

2270002054	Crushing/Proc. Equipment
2270002057	Rough Terrain Forklifts
2270002060	Rubber Tire Loaders
2270002063	Rubber Tire Dozers
2270002066	Tractors/Loaders/Backhoes
2270002069	Crawler Tractors

SCC	Diesel Equipment
2270002072	Skid Steer Loaders
2270002075	Off-Highway Tractors
2270002078	Dumpers/Tenders
2270002081	Other Construction Equipment
	Aerial Lifts
	Asphalt Pavers
	Other General Industrial Equipment
	Other Material Handling Equipment
	Forklifts
	Sweepers/Scrubbers

SIC-15 General Building Contractors

RESIDENTIAL CATEGORY

1521 General Contractors-Single-Family Houses
[23321 Single Family Housing Construction (pt)]
1531 Operative Builders
. Single Family Housing
[23321 Single Family Housing Construction (pt)]

COMMERCIAL CATEGORY

1522 General Contractors-Residential Buildings, Other Than Single-Family
. Hotel and Motel Construction
[23332 Commercial and Institutional Building Construction (pt)]
. Except Hotel and Motel Construction
[23322 Multifamily Housing Construction]
1531 Operative Builders
. Multifamily Housing
[23322 Multifamily Housing Construction]
. Manufacturing and Light Industrial Buildings
[23331 Manufacturing and Industrial Building Construction (pt)]
. Commercial and Institutional Buildings
[23332 Commercial and Institutional Building Construction (pt)]
1541 General Contractors-Industrial Buildings and Warehouses
. Public Warehouse Construction
[23332 Commercial and Institutional Building Construction (pt)]
. Except Public Warehouse Construction
[23331 Manufacturing and Industrial Building Construction (pt)]
1542 General Contractors-Nonresidential Buildings, Other than Industrial Buildings and Warehouses
[23332 Commercial and Institutional Building Construction (pt)]

SIC- 16 Heavy Construction Contractors

HIGHWAY/HEAVY CIVIL CATEGORY

1611 Highway and Street Construction, Except Elevated Highways
[23411 Highway and Street Construction (pt)]
1622 Bridge, Tunnel, and Elevated Highway Construction
[23412 Bridge and Tunnel Construction (pt)]
Also included in limited amounts:
1623 Water, Sewer, Pipeline, and Communications and Power Line Construction
. Water, Sewer and Pipelines
[23491Water, Sewer, and Pipeline Construction (pt)]
. Power and Communication Transmission Lines
[23492 Power and Communication Transmission Line Construction (pt)]

Attachment 1
Review of SIC/NAICS Codes for Construction Industry
(continued)

HIGHWAY/HEAVY CIVIL CATEGORY (continued)

1629 Heavy Construction, NEC
. Nonbuilding Structures Except Industrial Construction
[23499 All Other Heavy Construction (pt)]

MUNICIPAL/UTILITY CATEGORY

1623 Water, Sewer, Pipeline, and Communications and Power Line Construction
. Water, Sewer and Pipelines
[23491Water, Sewer, and Pipeline Construction (pt)]
. Power and Communication Transmission Lines
[23492 Power and Communication Transmission Line Construction (pt)]
1629 Heavy Construction, NEC
. Nonbuilding Structures Except Industrial Construction
[23499 All Other Heavy Construction (pt)]

INDUSTRIAL CATEGORY

1629 Heavy Construction, NEC
. Industrial Nonbuilding Structures Construction
[23493 Industrial Nonbuilding Structure Construction (pt)]

SIC – 17 Special Trades Contractors

These activities cut across all categories to some extent:
(Will be picked up by subcontractor interviews.)

1771 Concrete Work
. Stucco Construction
[23542 Drywall, Plastering, Acoustical, and Insulation Contractors (pt)]
. Except Stucco Construction
[23571 Concrete Contractors]
1781 Water Well Drilling
[23581 Water Well Drilling Contractors]
1791 Structural Steel Erection
[23591 Structural Steel Erection Contractors]
1794 Excavation Work
[23593 Excavation Contractors]
1795 Wrecking and Demolition Work
[23594 Wrecking and Demolition Contractors]

Attachment 1
Review of SIC/NAICS Codes for Construction Industry
(continued)

No substantial use of diesel construction equipment:

1711 Plumbing, Heating, and Air-Conditioning
[23511 Plumbing, Heating, and Air-Conditioning Contractors (pt)]
1721 Painting and Paper Hanging
[23521 Painting and Wall Covering Contractors (pt)]
1731 Electrical Work
[23531 Electrical Contractors]
1741 Masonry, Stone Setting, and Other Stone Work
[23541 Masonry and Stone Contractors]
1742 Plastering, Drywall, Acoustical, and Insulation Work
[23542 Drywall, Plastering, Acoustical, and Insulation Contractors (pt)]
1743 Terrazzo, Tile, Marble, and Mosaic Work
. Fresco Work
[23542 Drywall, Plastering, Acoustical, and Insulation Contractors (pt)]
. Except Fresco Work
[23543 Tile, Marble, Terrazzo, and Mosaic Contractors]
1751 Carpentry Work
[23551 Carpentry Contractors]
1752 Floor Laying and Other Floor Work, NEC
[23552 Floor Laying and Other Floor Contractors]
1761 Roofing, Siding, and Sheet Metal Work
[23561 Roofing, Siding, and Sheet Metal Contractors]
1793 Glass and Glazing Work
[23592 Glass and Glazing Contractors (pt)]
1796 Installation or Erection of Building Equipment, NEC
[23595 Building Equipment and Other Machinery Installation Contractors]
1799 Special Trade Contractors, NEC
. Paint and Wallpaper Stripping and Wallpaper Removal Contractors
[23521 Painting and Wall Covering Contractors (pt)]
. Tinted Glass Work
[23592 Glass and Glazing Contractors (pt)]
. Asbestos Abatement and Lead Paint Removal Contractors
[56291 Remediation Services (pt)]
. All Other Special Trade Contractors
[23599 All Other Special Trade Contractors]

List of Houston area construction contractors identified as contacts for emissions study.

Construction categories:

- Residential (single family)
- Commercial (commercial, office, light industrial, high-rise, apartments, etc.)
- Industrial/Petrochemical (chem/petrochem plant construction & maintenance)
- Municipal/Utilities (water/wastewater, other infrastructure)
- Highway/ Heavy Civil (highways, bridges, etc.)

Selection of developers and contractors working in the Residential category

Developers	**Contact**	**Telephone No.**
US Home	Don Lindsay	281-368-7700
Coles Crossing	Wayne Meyer	281-225-9000 x101
Holcomb Schubert	Jim Holcomb	713-843-0812 x204
Friendswood	Joe Stunja	281-874-8460
Todd Sherman	Michael Schaffer	713-626-8383
Summerwood	Lisa Nickel	281-225-1111
Kaufman Broad	Mike Rafferty	713-977-6633
Trendmaker	Rob Bamford	281-649-5207
South Shore Harbour	Jerry Jones	281-334-7501 x109
SUEBA	Wayne McLane	281-558-7599
Pulte	Kyle Davison	281-749-8000
The Woodlands	Bob Stout	281-719-6376
Cinco/Greatwood	Ted Nelson	281-398-0047
Lennar	Don Klein	281-875-1000 x475
Lake Olympia	Andrew Choy	713-975-9797
Blue Green	Kirk Wilhelm	281-324-9443
Johnson Development		713-960-9977
Newland Communities		512-658-5857
Land Tejas/Canyon Gates		713-783-6702

Contractors	Contact	Telephone No.
C.E. Barker	CE Barker	409-449-6737
Joel Trimm	Joel Trimm	281-375-5886
Lamb Const.	Kenneth Lamb	713-447-62__
Reddico	Ed Owens	281-350-1666
Jaho	Howard Kordell	281-446-4781
Texas Delta	Jimmy White	281-331-6922
Harris	Larry Harris	713-690-0791

Residential (continued)

Contractors	**Contact**	Telephone No.
Hurtado	Ben Vasquez	281-235-5492
Hassell Const.	Phil Hassell	281-893-2570
B&D Const.	Blake Hubbert	281-346-1009
Calco Const.	Henry Happel	281-448-2620
Wheaton Const.	Richard Wheaton	409-826-0404
Brazos River	Todd Harris	281-341-1600
Addicks	Jim Price	281-579-0795
Beyers	James Thompson	281-397-6011
Durwood Greene	Stephen Maynard	281-499-1551
L&W Excavators	C.J. Waller	281-489-1774
Lindsey Const.	Curtis Lindsey	713-826-0289
Park Const.	Bobby Park	281-342-0031
Pate & Pate	Steve Pate	281-353-1444
Triple B Services	Keith Burke	281-324-3264
Canyon Const.	Sam McClerry	281-489-3331
Colt Industries	Delores Tantillo	713-781-3345
E&C Const.	Cantrell	281-655-9800
Merdian	John	409-441-1944
R & B	Bryan Morrison	281-370-7442
Kinsel Industries	Daryl Black	713-641-5111
R Const.	Dudley Brewer	703-322-4639
Lonnie Listicha	Lonnie	409-865-5941
David Wight	David Wight	281-331-1584
Berry Plumbing		713-856-8503
Clearwater Const.		
Texas Sterling		
T&C Const.		
Allgood		

Selection of contractors working in the Commercial category

Contractors	**Contact**	**Telephone No.**
Dirt-Work Contractors		
AYG	Eddie Golan	(713) 748-2202
Benchmark	Jason Goin	(713) 462-6620
Murray Gobert	Darlene	(281) 540-2100
Concrete Contractors		
Baker Concrete	Tom Joiner	(713) 864-0657

Keystone	Mark Stewart	713-983-8002
TAS	Michael Burtshell	(281) 350-0832

Commercial (continued)

Steel Contractors	**Contact**	**Telephone No.**
Peterson-Beckner	Mike Fitzgerald	(281) 872-7722
Empire Steel	Steve Mobley	(281) 548-7377
Metro Erectors	Robert Parmer	(281) 487-2486

Selection of general contractors and subcontractors working in the Industrial/Petrochemical category

General Contractors	**Contact**	**Telephone No.**
Kellog / Brown & Root	Don Griswold	713-676-8718
Fluor Daniel	Bill Pender	281-263-1000
Becon (Bechtel Const.)	Earl Rapp	713-235-2000
JE Merit	George Delgado	713-669-8400
Zachry Construction Co.	Greg Atteberry	281-604-2200
Kvaerner	Steve Parks	713-988-2002
US Contractors	Rod Daigle	281-478-4828
Austin Industrial	Joe McKee	713-641-3400
The Mundy Co.	Ed Foster	281-530-8711

Subcontractors	**Contact**	**Telephone No.**
Cajun Contractors	Ronald Barber	281-479-5554
Deer Park Construction	Juilie Lyons	281-479-0020

Selection of general contractors working in the Municipal/Utility category

General Contractors	**Address**	**Contact**	**Telephone No.**
Champagne Webber	14333 Chrisman, Houston TX 77039	Charles Burnett	281-987-8787
Texas Sterling Construction	16630 Imperial Valley Dr. #242 Houston TX 77060	Pat Manning	281-999-7895
Kinsel Industries	8121 Broadway Houston TX 77061	Richard Kinsel	713-641-5111
Pate & Pate Enterprises	300 Valleywood Drive, The Woodlands TX 77380	Steve Pate	281-353-1444

Municipal/Utility (continued)

General Contractors	Address	Contact	Telephone No.
Allco, Inc.	P.O. Box 801246 Houston TX 77280-1246	Clyde Rice	713-461-2380
Hubco, Inc.	11714 Charles St. Houston TX 77041	Duane Gatlin	713-937-1100
Reddico Construction	10083 FM 1484 Conroe TX 77303	Ken Walker	409-441-9500
Jalco, Inc.	P.O.Box 27368 Houston TX 77227	Lee George	713-728-8480
BRH Garver	5402 Lawndale Houston TX 77023	Mike Garver	713-921-2929

Selection of general contractors and subcontractors working in the Heavy Civil/Highway category

General Contractors	Contact	Telephone No.
Williams Brothers	Bob Lanham	713-522-9821
Balfour Beatty	Bill Miller	512-707-0797

Subcontractors	Contact	Telephone No.
Beck Foundation	Charles Knapp	713-933-5100
Bell Bottom Drilling	Joe Wilkins	281-485-2791
Webber-Balke Drilling	Shan Balke	281-498-7935
L.A. Utilities	Jim Toungate	281-499-0550
Vicon Services	George Vick	281-391-8601
Jimerson Underground	Tom Nugent	281-261-2066
Bortunco	Dale Kornegay	713-799-1200
MICA Corporation	Mike Walsh	713-896-4288
Florida Traffic Control	George Williams	281-992-3030

Appendix D

Confidentiality Agreement

MEMORANDUM ON TREATMENT OF CERTAIN INFORMATION OBTAINED DURING SITE VISITS BY THE HOUSTON-GALVESTON AREA COUNCIL CONTRACTOR REPRESENTATIVES

A. _____ (hereinafter referred to as "Company") agrees to provide, or give access to, for the limited purpose stated at the end of this paragraph and on the terms stated in this Memorandum, information reasonably requested by and for the Houston Galveston Area Council (hereinafter "HGAC") through its contractor representative, **Eastern Research Group, Inc.** (hereinafter "ERG") for ERG's use, and that of its employees, for the benefit of HGAC in the course of carrying out ERG's work responsibilities pursuant to HGAC's Project Number TS 9420. The information and data requested may be either documentary (e.g., records, charts, or electronic data) or non-documentary (e.g., oral communications, expert opinions, or visual observations). The sole purpose for the information and data requested is to assist in the development of an emissions inventory attributable to construction activity in the Houston-Galveston Area.

B. ERG will seek to acquire information from Company, including, but not limited to, information relating to Company owned equipment, equipment specifications, and equipment usage patterns. ERG will conduct interviews of Company staff including site personnel and/or administrative staff. After the requested information has been collected by ERG from Company, ERG will provide all documentary data to the Associated General Contractor's representative, Starcrest Consulting. (The Associated General Contractors will serve as the representative of and for the Houston Construction Industry Coalition (HCIC).) Starcrest Consulting will subsequently remove all references to the Company's identity, and return the modified information and data to ERG for further evaluation and analysis to facilitate development of the inventory. The information and data collected from Company by ERG will be compiled into an extensive database made up of similar information gathered from other firms working in or related to the construction industry. ERG shall perform statistical analyses of the database information and will furnish its data and findings to HGAC, provided however that all data presented to HGAC, or any third party authorized by HCIC, shall be in a summary statistical format and will not identify the Company source of the data.

C. ERG acknowledges that the data and information furnished by the Company shall remain the Company's. Information and data as analyzed by ERG shall remain the sole property of the HCIC. ERG does retain the limited right to use the Company's furnished information, as modified by Starcrest Consulting, for the purposes of carrying out the work required under the above-referenced Project Number. When the gathered information is no longer required by ERG for the performance of the work for HGAC, ERG agrees to return all the information collected from the Company, and subsequently compiled in the database, to the AGC. ERG shall protect the sensitive nature of the information collected from Company, by exercising the same reasonable degree of care, to prevent the unauthorized use, dissemination, or disclosure of the information, as ERG uses to protect its own sensitive technical information. ERG shall take reasonable and appropriate measures to safeguard such sensitive information from theft, loss and unauthorized disclosure, and to limit access to such information to employees who reasonably require access in order to accomplish the work.

D. This Memorandum does not address information not obtained from the Company.

ERG and Company acknowledge that they have read the entire Memorandum, expressly understand it, and agree to comply with its terms. Nothing contained in this Memorandum shall be construed to create a joint venture or partnership between ERG and Company.

Eastern Research Group, Inc.

By: _____

Name: _____

Title: _____

Date: _____

Company: _____

By: _____

Name: _____

Title: _____

Date: _____

Appendix E

Equipment Survey Forms – by Sector

CONSTRUCTION EQUIPMENT DATA QUESTIONNAIRE – HEAVY-HIGHWAY SECTOR

Name of Company/Organization:

_____

_____

Address:

_____

_____

Location of significant construction activity in the 8 county Houston/Galveston area (Harris, Brazoria, Ft. Bend, Montgomery, Galveston, Chambers, Liberty, and Waller counties) between 9/1/98 - 8/31/99:

_____

_____

Equipment types of interest:

_____

_____*In the blank to the left of each equipment type, please list the number of equipment pieces owned and operated by your company/organization between 9/1/98 - 8/31/99 in the 8 counties.

****Includes only diesel equipment > 25 hp.**

#	Equipment Type	#	Equipment Type	#	Equipment Type
	Aerial Lifts	_	Forklifts		Rough Terrain Forklifts
	Asphalt Pavers		Graders		Rubber Tire Dozers
	Bore/Drill Rigs		Off-Highway Tractors		Rubber Tire Loaders
	Cement and Mortar Mixers		Off-highway Trucks		Scrapers
	Concrete/Industrial Saws		Other Construction Equipment		Signal Boards
	Concrete Pavers		Other General Industrial Equipment		Skid Steer Loaders
	Cranes		Other Material Handling Equipment		Surfacing Equipment
	Crawler Tractors		Pavers		Sweepers/Srubbers
	Crushing/Proc. Equipment		Paving Equipment		Tampers/Rammers
	Dumpers/Tenders		Plate Compactors		Tractors/Loaders/Backhoes
	Excavators		Rollers		Trenchers

Please complete the following table for each piece of equipment listed above:

Equipment Type	Horsepower (or engine make/model)	Hours of Operation by Month (September 1, 1998 B August 31, 1999)									
		Sep 98	Oct 98	Nov 98	Dec 98	Jan 99	Feb 99	Mar 99	Apr 99	May 99	Jun 99

ADDITIONAL INFORMATION – (Note: There is no need to answer questions 3 -12 at this time – our staff will cover these questions with you in person during the on-site interview.)

1. If available, please provide an estimate of **total** off-road (high-sulfur) diesel use for the target period, 9/1/98 - 8/31/99:

_____

_____

2. Please provide an estimate of **total** revenue and the number of field employees for the target period, 9/1/98 - 8/31/99, company-wide as well as for the 8 county area alone:

_____

_____

3. For each equipment type used in your activities, please describe their use profile –

   i) Daily (e.g., an hour of down time early mornings and late afternoons);
   ii) Weekly (e.g., only 4 hours of engine use on Saturdays, none on Sundays).

_____

_____

4. Was Fiscal 1999 a representative year for your company's activity? If not, how could your estimates be adjusted to be more representative?

_____

_____

5. Qualitatively, how would you estimate future year growth for your company?

_____

6. What sort of factors lead to significant variations in the way your equipment is used in the 8 county area (e.g., soil type, topography, rain/heat, etc.)?

_____

_____

7. In your opinion, is older equipment used any differently than newer equipment?

_____

_____

8. Is rented equipment used any differently than owned equipment (for the same type of equipment)?

_____

_____

9. For equipment you own, what percentage was purchased before 1990?

_____

_____

10. What percentage was purchased from outside the 8 county area?

_____

_____

11. What percentage of total engine hours occurred outside the 8 county area, for the equipment listed?

_____

CONSTRUCTION EQUIPMENT DATA QUESTIONNAIRE - INDUSTRIAL / PETROCHEMICAL

Name of Company/Organization:

_____

_____

Address:

_____

_____

Location of significant construction activity in the 8 county Houston/Galveston area (Harris, Brazoria, Ft. Bend, Montgomery, Galveston, Chambers, Liberty, and Waller counties) between 9/1/98 - 8/31/99:

_____

_____

Equipment types of interest:

In the blank to the left of each equipment type, please list the number of equipment pieces owned and operated by your company/organization between 9/1/98 - 8/31/99 in the 8 counties.

****Includes only diesel equipment > 25 hp.**

#	Equipment Type	#	Equipment Type	#	Equipment Type
					Rough Terrain Forklifts
	Asphalt Pavers		Graders		Rubber Tire Dozers
	Bore/Drill Rigs		Off-Highway Tractors		Rubber Tire Loaders
	Cement and Mortar Mixers		Off-highway Trucks		Scrapers
	Concrete/Industrial Saws		Other Construction Equipment		Signal Boards
	Concrete Pavers				Skid Steer Loaders
	Cranes				Surfacing Equipment
	Crawler Tractors		Pavers		
	Crushing/Proc. Equipment		Paving Equipment		
			Plate Compactors		Tractors/Loaders/Backhoes
	Excavators		Rollers		Trenchers

Please complete the following table for each piece of equipment listed above:

Equipment Type	**Horsepower (or engine make/model)**	**Hrs/Yr (9/1/98 – 8/31/99)**	**Age (Model Year)**

ADDITIONAL INFORMATION

1. For each equipment type used in your activities, please describe their use profile -

C Daily;
C Weekly;
C Monthly/Seasonally.

2. What were the total man-hours during FY 99 for construction (turnaround, maintenance, other) activities in the 8 county area?

3. If available, please provide an estimate of **total** off-road diesel use for the target period, 9/1/98 - 8/31/99, for listed equipment:

4. In your opinion, is older equipment used any differently than newer equipment?

5. Was Fiscal 1999 a representative year for your company's activity? If not, how should your estimates be adjusted?

6. What percentage of diesel construction equipment is rented? Is rented equipment used any differently than owned equipment (for the same type of equipment)?

7. For equipment you own, roughly what percentage was purchased before 1990?

8. Roughly, what percentage was purchased from outside the 8 county area?

9. Roughly, what percentage of diesel equipment activity comes from subcontractors?

CONSTRUCTION EQUIPMENT DATA QUESTIONNAIRE - MUNICIPAL / UTILITY CONTRACTORS

Name of Company/Organization:

_____

_____

Address:

_____

_____

Location of significant construction activity in the 8 county Houston/Galveston area (Harris, Brazoria, Ft. Bend, Montgomery, Galveston, Chambers, Liberty, and Waller counties) between 9/1/98 - 8/31/99:

_____

_____

Equipment types of interest:

*In the blank to the left of each equipment type, please list the number of equipment pieces owned and operated by your company/organization between 9/1/98 - 8/31/99 in the 8 counties.

****Includes only diesel equipment > 25 hp.**

#	Equipment Type	#	Equipment Type	#	Equipment Type
					Rough Terrain Forklifts
	Asphalt Pavers		Graders		Rubber Tire Dozers
	Bore/Drill Rigs		Off-Highway Tractors		Rubber Tire Loaders
	Cement and Mortar Mixers		Off-highway Trucks		Scrapers
	Concrete/Industrial Saws		Other Construction Equipment		Signal Boards
	Concrete Pavers				Skid Steer Loaders
	Cranes				Surfacing Equipment
	Crawler Tractors		Pavers		
	Crushing/Proc. Equipment		Paving Equipment		
			Plate Compactors		Tractors/Loaders/Backhoes
	Excavators		Rollers		Trenchers

Please complete the following table for each piece of equipment listed above:

Equipment Type	Horsepower (or engine make/model)	Hrs/Yr (9/1/98 – 8/31/99)	Age (Model Year)

ADDITIONAL INFORMATION

1. For each equipment type used in your activities, please describe their use profile -

C Daily;
C Weekly;
C Monthly/Seasonally.

2. If available, please provide an estimate of **total** off-road (high-sulfur) diesel use for the target period, 9/1/98 - 8/31/99 for listed equipment:

3. Please provide an estimate of **total** revenue and number of field employees for the target period, 9/1/98 - 8/31/99, for the 8 county area:

4. In your opinion, is older equipment used any differently than newer equipment?

5. Was Fiscal 1999 a representative year for your company's activity? If not, how should your estimates be adjusted?

6. What percentage of diesel construction equipment is rented? Is rented equipment used any differently than owned equipment (for the same type of equipment)?

7. For equipment you own, roughly what percentage was purchased before 1990?

8. Roughly, what percentage was purchased from outside the 8 county area?

9. Please describe any subcontractor equipment and activity used on your projects during the target period.

_____

_____

_____

Appendix F

Gulf Coast Workforce Survey Participants

Chevron
ISK Bioscience
Union Carbide
BP Amoco
Georgia Gulf
Fina Oil
Solvay Polymers
Nalco/Exxon
Safety Kleen
Huntsman
Lyondell Chemical
Sterling Chemical
Reliant Energy
Bayer
Oxy Chem
Lyondell-Citgo Refining
Air Products
Equistar Chemicals
Elf AtoChem
Lubrizol
Solutia
Dow Chemical
Rohm & Haas
Kaneka
Millennium
ExxonMobil
Celanese
Phillips Chemical
Phillips Petroleum
BASF
Praxair
Aristech
Shell Chemical

Shell Deer Park Refining

Dallas-Ft. Worth Area Construction Equipment Population Estimates

March 22, 2000

Prepared for

The Texas Natural Resource Conservation Commission SIP Modeling Section

Prepared by

Rick Baker
Eastern Research Group

INTRODUCTION

Eastern Research Group (ERG) recently completed a detailed assessment of construction equipment ownership and use in the Houston area. This study relied upon surveys of equipment operators to estimate total equipment populations and activity levels for diesel construction equipment greater than 25 horsepower operating in the 8 county Houston ozone non-attainment area. Separate estimates were developed for equipment in the following sectors:

- Heavy-Highway Construction
- Municipal/Utility Contractors
- Municipalities and Counties owning and operating equipment
- Chemical/Petrochemical Industry Construction, Maintenance, and Turnaround Activities
- Commercial Construction
- Residential Construction
- Rental Companies

The preliminary results indicate that previous estimates of construction equipment numbers and activity (and therefore emissions) for the Houston area have been overestimated by more than 50%.

The TNRCC subsequently contracted with ERG to develop updated equipment population and activity estimates for the 4 county Dallas/Ft. Worth ozone non-attainment area to facilitate air quality modeling and control assessments for the region.[35] Given the limited time available for the analysis it was not possible to perform additional surveys for construction sources in the Dallas area, as was done for Houston. Therefore ERG developed a methodology for extrapolating the findings for Houston to the Dallas area. Specifically, ERG identified surrogates for the 4 county area similar to those used for the Houston study. Different surrogates were developed for each of the sectors listed above. Once identified, these surrogates were divided by the corresponding Houston surrogates to develop scaling factors for each sector. ERG estimated total Dallas area equipment populations for each sector by multiplying these scaling factors by the sector-specific Houston equipment populations. (Note that activity estimates established for Houston equipment were not modified.) These scaling factors are summarized in Table 1 below for each sector.

Therefore Table 1 indicates that the 4 county Dallas fleet is approximately 20% larger than the 8 county Houston fleet (19,698 and 16,400, respectively). The attached spreadsheets provide the detailed dollar values and related information used to determine the scaling factors.

---

[35] Counties include Dallas, Tarrant, Collin, and Denton.

Table 1
Dallas/Houston Scaling Factors, by Sector

Sector	Surrogate Basis	Scaling Factor
Heavy-Highway	FY 1999 TXDOT letting values	0.722
Municipal/Utility Contractors	1999 Contract award values, Amtec database	1.336
Municipalities and Counties	1999 Population	0.924
Industrial	N/A	0.0
Commercial	1999 Contract values	1.739
Residential	1998-9 Single family permits/lot completions	1.124
Rental	Total contract value for other sectors	1.382
Total Fleet	**1.20**	

The following summarizes the methodology and assumptions used to develop these scaling factors for each sector. Potential sources of uncertainty associated with these extrapolations are also discussed.

Heavy-Highway

The extrapolations for this sector were based upon TXDOT contract lettings for the 4 county area for fiscal year 1999 – the same surrogate used for the Houston study. According to Bob Lanham, Vice President of Williams Brothers Construction, equipment activity levels per mile of highway in Houston and Dallas are essentially identical.[36] Letting values were adjusted to reflect slightly higher labor costs for the Dallas region (~10%, as per Bob Lanham). To be conservative letting values were not adjusted for the slightly lower materials costs in Dallas. Therefore ERG believes this method yields very reasonable, reliable, and slightly conservative estimates of equipment populations for this sector (~610 pcs of equipment, excluding cranes).

Municipal/Utility Contractors

ERG obtained estimates of contract award values for the 4 county area in 1999, for all municipal and county utility contracts. These data were obtained from the same database used to estimate the Houston surrogates (Amtec). A labor correction factor of 10% was applied in the same manner as was done for the Highway sector. Results indicate that activity levels are about 33% higher in Dallas than in Houston. This finding is in agreement with local expert assessments that Dallas has recently experienced a rapid upturn in bond issues and utility infrastructure investment

[36] Personal communication, March 1, 2000.

over the last few years.[37] Using this factor ERG estimated 4,904 pieces of equipment for this sector, excluding cranes.

Municipalities and Counties

1999 population estimates were used as the basis for projecting equipment populations for this sector. This approach assumes that roughly the same amount and type of equipment will be needed on a per capita basis for the routine, small scale activities performed by the municipalities and counties, regardless of the area in question. (This assumption should be relatively independent of fluctuations typically seen with bond-issue and other large utility projects – see Municipal/Utility Contractors above). The resulting population ratio of 0.924 yields an estimated 1,700 pieces of equipment for this sector, excluding cranes.

Industrial Sector

According to local construction experts and knowledgeable TNRCC staff, there are no significant chemical/petrochemical or other related facilities in the 4 county area.[38] Therefore ERG assumed 0 equipment for this sector.

Commercial

Equipment activity in the commercial sector was based on contract values for 1999, for both Houston and Dallas. Dallas contract values were projected using data obtained from the Texas A&M University Real Estate Center for "Non-Residential" and "Multi-Family" permit values for each of the 4 counties. Since data were not available for the most recent years, ERG projected 1999 contract values from 1991 through 1995 data using linear regression. This method introduces additional uncertainty into the equipment count projections, and should be modified using actual data if available. However, the estimates are still likely to be conservative, since higher land prices in the Dallas area will artificially inflate projected equipment activity levels under this method. Estimates of owned equipment for this sector were 464 pieces, excluding cranes.

Residential

Projections for this sector relied upon slightly different factors for Dallas than were used for Houston. Specifically, ERG obtained single family permit values for 1998 for Dallas from the

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[37] Si McHugh, President, Associated General Contractors, Dallas Chapter, personal communication, March 2, 2000.
[38] Si McHugh, President, Associated General Contractors, Dallas Chapter, personal communication, March 2, 2000.

Texas A&M database, compared to 1999 lot completion estimates for the Houston area. Nevertheless, these surrogates are quite comparable and should provide a reliable scaling factor. In fact, we expect projections based on Houston data to be conservative for this sector, since most developments in the Dallas area would not require land clearing as was assumed for Houston. Using the resulting scaling factor yielded 1,273 pieces of equipment for this sector.

Rental

This is the only sector for which ERG was not able to obtain surrogates similar to those used in the Houston analysis. Specifically, the Houston study collected appraised equipment values from the county tax office as the basis for determining market share for this sector. However, given limited time and resources ERG was not able to obtain similar data for the Dallas area. As an alternative ERG assumed that total construction contract values across all sectors could be used to estimate the overall size of the rental market for a given area. Since ERG did not have dollar value estimates for the residential sector, we obtained average dollar values per unit of construction for each county from the Texas A&M database. ERG multiplied these values by the estimated number of units permitted/completed per year to obtain annual dollar valuations for this sector. Summing the estimated dollar values for the Highway, Municipal/Utility contractor, Commercial, and Residential sectors for each area and taking the ratios, ERG estimated 8,166 pieces of equipment for rental companies in the 4 county area, excluding cranes.

Cranes

The Houston study did not develop reliable estimates for crane populations and activity, due to a poor response rate among crane rental companies in the area. Therefore ERG recommended adopting the values generated by EPA's NONROAD model for area. Based on the findings for other equipment types, the NONROAD model consistently overestimated equipment populations for the Houston area. Therefore we believe reliance on NONROAD estimates for crane populations in the Dallas area are also likely to be conservative. Total crane counts for this sector were estimated at 2,525, compared to 1,619 for Houston. Given the lack of Industrial-related construction in the area, ERG believes this estimate is extremely conservative.

				17292	total	
EQUIP	**HPMN**	**HPMX**	**8 Co Pop**	**Ttl Hrs**	**Ttl Hr/unit**	**Avg Hr/Unit (across hp range) -- for Activity File update**
PAVER1	25	40	12	6390	533	709
PAVER2	40	50	6	1265	211	
PAVER3	50	100	4	3141	785	
PAVER4	100	175	81	55347	683	
PAVER5	175	300	90	71291	792	
PAVER6	300	600	1	56	56	
ROLLER1	25	40	104	41164	396	549
ROLLER2	40	50	53	17415	329	
ROLLER3	50	100	544	317699	584	
ROLLER4	100	175	905	514842	569	
ROLLER5	175	300	43	14830	345	
ROLLER6	300	600	2	135	68	
SCRAPER3	50	100	1	14	14	455
SCRAPER4	100	175	1	652	652	
SCRAPER5	175	300	31	13402	432	
SCRAPER6	300	600	3	2468	823	
SCRAPER7	600	750	1	311	311	
PAVING EQUIPMENT1	25	40	1	82	82	344
PAVING EQUIPMENT2	40	50	7	499	71	
PAVING EQUIPMENT3	50	100	28	1690	60	
PAVING EQUIPMENT4	100	175	13	12461	959	

PAVING EQUIPMENT5	175	300	41	16255	396	
SURFACING EQUIPMENT4	100	175	176	104756	595	573
SURFACING EQUIPMENT5	175	300	12	4229	352	
SURFACING EQUIPMENT6	300	600	285	162031	569	
SURFACING EQUIPMENT7	600	750	16	9415	588	
SIGNAL BOARD1	25	40	157	82967	528	528
SIGNAL BOARD2	40	50	0	0	0	
SIGNAL BOARD3	50	100	0	0	0	
SIGNAL BOARD4	100	175	0	0	0	
SIGNAL BOARD5	175	300	0	0	0	
TRENCHER1	25	40	19	10419	548	601
TRENCHER2	40	50	82	60175	734	
TRENCHER3	50	100	127	72671	572	
TRENCHER4	100	175	4	1551	388	
TRENCHER5	175	300	4	358	89	
TRENCHER6	300	600	4	291	73	
TRENCHER7	600	750	2	50	25	
TRENCHER8	750	1500	0	0	0	
BOER/DRILL RIG1	25	40	4	1754	439	513
BOER/DRILL RIG2	40	50	1	50	50	
BOER/DRILL RIG3	50	100	28	39434	1408	
BOER/DRILL RIG4	100	175	10	10518	1052	
BOER/DRILL RIG5	175	300	597	276896	464	
BOER/DRILL RIG6	300	600	1	371	371	
BOER/DRILL RIG7	600	750	1	414	414	
BOER/DRILL RIG8	750	1000	0	0	0	

EXCAVATOR1	25	40	61	28805	472	764
EXCAVATOR2	40	50	42	16736	398	
EXCAVATOR3	50	100	260	133880	515	
EXCAVATOR4	100	175	869	546092	628	
EXCAVATOR5	175	300	871	837715	962	
EXCAVATOR6	300	600	230	221035	961	
EXCAVATOR7	600	750	2	335	168	
EXCAVATOR8	750	1000	0	0	0	
EXCAVATOR9	1000	2000	0	0	0	
CONCRETE / INDUSTRIAL SAW1	25	40	18	9897	550	508
CONCRETE / INDUSTRIAL SAW2	40	50	10	5321	532	
CONCRETE / INDUSTRIAL SAW3	50	100	67	32837	490	
CONCRETE / INDUSTRIAL SAW4	100	175	11	5749	523	
CEMENT/MORTAR MIXER3	50	100	0	0	0	#DIV/0!
CRANE1	25	40	0	N/A	0	806
CRANE2	40	50	31	N/A	0	
CRANE3	50	100	236	N/A	0	
CRANE4	100	175	648	N/A	0	
CRANE5	175	300	552	N/A	0	
CRANE6	300	600	144	N/A	0	
CRANE7	600	750	8	N/A	0	
GRADER1	25	40	3	172	57	717
GRADER2	40	50	2	23	12	
GRADER3	50	100	60	16444	274	
GRADER4	100	175	457	350326	767	
GRADER5	175	300	184	139590	759	
GRADER7	300	750	2	1168	584	

OFF HIGHWAY TRUCK4	100	175	8	3856	482	1257
OFF HIGHWAY TRUCK5	175	300	10	3833	383	
OFF HIGHWAY TRUCK6	300	600	0	0	0	
OFF HIGHWAY TRUCK7	600	750	0	0	0	
OFF HIGHWAY TRUCK8	750	1000	39	63987	1641	
OFF HIGHWAY TRUCK9	1000	1500	0	0	0	
OFF HIGHWAY TRUCK10	1500	2000	0	0	0	
OFF HIGHWAY TRUCK11	2000	3000	0	0	0	
CRUSHING/PROCESSING EQUIPMENT1	25	40	0	0	0	#DIV/0!
CRUSHING/PROCESSING EQUIPMENT2	40	50	0	0	0	
CRUSHING/PROCESSING EQUIPMENT3	50	100	0	0	0	
CRUSHING/PROCESSING EQUIPMENT4	100	175	0	0	0	
CRUSHING/PROCESSING EQUIPMENT5	175	300	0	0	0	
CRUSHING/PROCESSING EQUIPMENT6	300	600	0	0	0	
CRUSHING/PROCESSING EQUIPMENT7	600	750	0	0	0	
(NOTE -- Category assigned to OTHER)						
ROUGH TERRAIN FORKLIFT1	25	40	3	1318	439	1041
ROUGH TERRAIN FORKLIFT2	40	50	7	3959	566	
ROUGH TERRAIN FORKLIFT3	50	100	359	369305	1029	
ROUGH TERRAIN FORKLIFT4	100	175	101	116644	1155	
ROUGH TERRAIN FORKLIFT5	175	300	1	8	8	
ROUGH TERRAIN FORKLIFT6	300	600	1	2	2	
RUBBER TIRE LOADER1	25	40	2	43	21	858
RUBBER TIRE LOADER2	40	50	2	167	83	
RUBBER TIRE LOADER3	50	100	55	29106	529	
RUBBER TIRE LOADER4	100	175	856	691719	808	
RUBBER TIRE LOADER5	175	300	305	327189	1073	
RUBBER TIRE LOADER6	300	600	2	706	353	

RUBBER TIRE LOADER7	600	750	2	1099	549	
RUBBER TIRE LOADER8	750	1000	0	0	0	
RUBBER TIRE LOADER9	1000	1500	0	0	0	
RUBBER TIRE LOADER10	1500	2000	0	0	0	
RUBBER TIRE LOADER11	2000	3000	0	0	0	
RUBBER TIRE TRACTOR/DOZER4	100	175	90	48279	536	466
RUBBER TIRE TRACTOR/DOZER5	175	300	2	1721	861	
RUBBER TIRE TRACTOR/DOZER6	300	600	20	2172	109	
RUBBER TIRE TRACTOR/DOZER7	600	750	0	0	0	
RUBBER TIRE TRACTOR/DOZER8	750	1000	0	0	0	
TRACTOR/LOADER/BACKHOE1	25	40	120	51536	429	765
TRACTOR/LOADER/BACKHOE2	40	50	40	21000	525	
TRACTOR/LOADER/BACKHOE3	50	100	2688	2102484	782	
TRACTOR/LOADER/BACKHOE4	100	175	357	266982	748	
TRACTOR/LOADER/BACKHOE5	175	300	20	24300	1215	
CRAWLER TRACTOR/DOZER1	25	40	6	690	115	819
CRAWLER TRACTOR/DOZER2	40	50	3	142	47	
CRAWLER TRACTOR/DOZER3	50	100	1012	694038	686	
CRAWLER TRACTOR/DOZER4	100	175	685	555463	811	
CRAWLER TRACTOR/DOZER5	175	300	404	481315	1191	
CRAWLER TRACTOR/DOZER6	300	600	16	9811	613	
CRAWLER TRACTOR/DOZER7	600	750	2	1915	958	
CRAWLER TRACTOR/DOZER8	750	1000	0	0	0	
SKID STEER LOADER1	25	40	49	34466	703	844
SKID STEER LOADER2	40	50	170	89312	525	
SKID STEER LOADER3	50	100	1224	1095804	895	
SKID STEER LOADER4	100	175	2	18	9	

OFF HIGHWAY TRACTOR4	100	175	3	1764	588	853
OFF HIGHWAY TRACTOR5	175	300	3	1956	652	
OFF HIGHWAY TRACTOR6	300	600	1	245	245	
OFF HIGHWAY TRACTOR7	600	750	2	3711	1855	
OFF HIGHWAY TRACTOR8	750	1000	0	0	0	
OFF HIGHWAY TRACTOR9	1000	1500	0	0	0	
OTHER CONSTRUCTION EQUIPMENT1	25	40	20	8204	410	516
OTHER CONSTRUCTION EQUIPMENT2	40	50	6	2018	336	
OTHER CONSTRUCTION EQUIPMENT3	50	100	145	52065	359	
OTHER CONSTRUCTION EQUIPMENT4	100	175	74	38450	520	
OTHER CONSTRUCTION EQUIPMENT5	175	300	49	37178	759	
OTHER CONSTRUCTION EQUIPMENT6	300	600	56	42802	764	
			17292	11558667		

DALLAS/FT. WORTH 4 COUNTY AREA CONSTRUCTION EQUIPMENT POPULATION ESTIMATES

Base Yr -- 1999

Municipal/Utility Sector

Basis -- 1998 Population Ratios

4 County DFW Population	4,144,200
8 County HGA Population	4,482,649
Sector Scaling Factor	0.924

Municipal Utility Contractor Sector

Basis -- Amtec Data base of contract values awarded by municipalities and counties

4 County DFW Value	$1,599,671,794	
8 County HGA Value	$1,179,277,017	
DFW Labor Cost Increase	10%	(Bob Lanham, President AGC of Texas, Heavy Highway, Utilities and Industrial Branch)
HGA Non-labor cost fraction	85%	(Bob Lanham, President AGC of Texas, Heavy Highway, Utilities and Industrial Branch)
Labor corrected HGA value	$1,196,966,172	
Sector Scaling Factor	1.336	

Commercial Sector

Basis -- 1999 Nonresidential permit values

4 County DFW Value	$2,012,015,327	(from TAMU Real Estate Center -- projected to 1999 using monovariate regression based on 1991 through 1995 data)
8 County HGA Value	$1,157,000,000	(from Greater Houston Partnership estimate for calendar year 99, New Nonresidential permit values)

Sector Scaling Factor 1.739

Residential Sector

Basis -- Single family building permits/lot completions

4 County DFW Permit #	29,924	(1998 building permits issued from TAMU Real Estate Center)
8 County HGA # Lot Completions	26,618	(from American Metro Studies Database for new single family lot completions, 1999)

Sector Scaling Factor 1.124

Industrial Sector

Assumed to be zero in 4 county area; cranes to be left at default NONROAD values

Heavy-Highway Sector

Basis -- FY 99 Lettings from TXDOT within target counties + local labor cost correction factor

4 County DFW Value	$ 359,262,324	
8 County HGA Value	$ 490,000,000	
DFW Labor Cost	10%	(Bob Lanham, President AGC of Texas, Heavy Highway, Utilities and

Increase		Industrial Branch)
HGA Non-labor cost fraction	85%	(Bob Lanham, President AGC of Texas, Heavy Highway, Utilities and Industrial Branch)
Labor corrected HGA value	$ 497,350,000	
Sector Scaling Factor	0.722	

Rental Sector

Basis -- Total construction dollar volume from all other sectors combined, less industrial and muni/counties (but including their contract work)

Residential

4 County DFW Value	$4,291,182,800	(from TAMU Real Estate Center -- calculated from average home price and total units)
8 County HGA Value	$3,143,115,900	(from TAMU Real Estate Center -- calculated from average home price and total units)

Municipalities and Counties

4 County DFW Value	$1,599,671,794
8 County HGA Value	$1,179,277,017

Total -- All Sectors

4 County DFW Value	$8,262,132,245
8 County HGA Value	$5,976,742,917

Sector Scaling Factor	1.382

Dallas-Ft. Worth Area Construction Equipment Population Estimates

ADDENDUM

Response to Comments from USEPA Region 6

April 4, 2000

USEPA has provided informal comments regarding ERG's Draft Report, Dallas-Ft. Worth Area Construction Equipment Population Estimates, submitted to the TNRCC and EPA on March 22, 2000. The following provides a response to EPA's comments and requests for additional data.

Use of Default Activity Factors from the Draft NONROAD Model

During the course of data collection there were certain instances where equipment-specific activity factors were not available. In these instances ERG relied upon default hour per year estimates from the draft NONROAD model. For all but three equipment classes the NONROAD activity estimates were approximately equal to or higher than the survey average, leading to more conservative (i.e., higher) hour per year estimates. However, for three equipment classes the NONROAD estimates were lower than the sample average. In these cases emissions estimates were actually lowered due to this approach. Table 1 summarizes the number of equipment pieces relying on default hour per year estimates, compared to the projected number for the entire area.[39]

Table 1
Default Hour Per Year Assignments

Equipment Type	Total #	Default Assignments	% Assigned	Per Unit Activity Increase
Bore/Drill Rigs	642	595	93%	10%
Rubber Tire Loaders	1,224	433	35%	13%
Rough Terrain Forklifts	472	42	9%	57%

First note that for two of the three equipment types the per unit increase in activity is relatively small – between 10% and 15%. In addition, while the per unit increase is much more significant for rough terrain forklifts, only 42 of these units were actually assigned

[39] Numbers reported for Houston area study – Dallas extrapolations are directly scaled from the Houston data for all equipment types, excluding cranes.

NONROAD activity values. Therefore we believe that the overall effect on total tpd emission estimates should be minimal for all three of these equipment types. Nevertheless, emissions estimates could easily be scaled up for these categories at the request of EPA.

Stratified Survey Response Rates

As noted in the report the largest construction companies were identified through market share assessments. Surveys were subsequently conducted for these larger companies. Within the targeted segment the survey response rates were relatively high. Table 2 summarizes the response rates, by construction sector, for the universe of targeted sources.

Table 2
Stratified Survey Response Rates, by Sector

Sector	# of Responses	Rate	Non-Responding Surrogate Fraction
Highway	11 of 12	92%	1.2%
Industrial	5 of 11	45%	Uncertain*
Utility Contractor	10 of 12	83%	~1%
Cities/Counties	24 of 26	92%	~1.4%
Rental	22 of 107	21%	71.5%

* Surrogate data was available only for responding sources, and as an aggregated total for this sector.

As can be seen from the table, survey response rates were very high for most sectors. Only the Rental sector witnessed a relatively low response rate. Please note, however, that the response rates reported above are only for those sources selected for surveying, not for the sector as a whole. The right-hand column provides an indication of the importance of the non-responding sources to the sector as a whole.

Recommendations

The following provides several recommendations for improving the accuracy and precision of the current inventory. The recommendations are listed roughly in order of importance, based on ERG's qualitative assessment of likely impacts on the inventory.

- A time series evaluation is needed for the surrogates selected for each sector to determine the representativeness of the base year. Based on communications with numerous estimators and local experts, 1999 appears to have been a “boom” year for most/all of the construction industry in Texas. Therefore we would expect any adjustments along these lines to lower overall emissions in 2007.
- A determination of the population in unincorporated areas in the Houston region should be obtained to refine the estimate of City/County equipment populations. The current approach almost certainly grossly overestimates equipment counts for these “non-surveyed” areas.
- A separate survey of crane rental companies should be undertaken, similar to that performed for the rest of the rental sector. Based on the results seen for other equipment types, reliance upon NONROAD equipment population and activity estimates probably overestimates crane emissions significantly.
- The TNRCC could perform an analysis of fleet turnover effects using the extensive model year data gathered during the survey. On first glance it appears that the Houston area fleet may be somewhat newer than assumed in the NONROAD model, due primarily to the young age of the rental fleet as a whole. This in turn could result in lower future year emissions due to increased penetration of Tier 2 and 3 technologies.
- The NONROAD default engine load factors could also be revised based on the fuel consumption data collected during the survey. Preliminary indications are that the NONROAD load factors should be adjusted downward, thereby lowering emissions projections.
- Appraised equipment values should be obtained for rental companies identified outside of Harris County. (This effort is already underway for the 4 Dallas area counties.)
- For those rental companies responding to the surveys, additional information should be gathered on equipment not included in the original survey form (i.e., “non-construction” equipment.) This information will help refine the appraised equipment value estimates for extrapolation to the remainder of the rental sector.
- A more detailed survey of Reliant Energy contractors could improve the accuracy of this small portion of the inventory.

Written by Nonroad interface at 5/6/1999 3:30:22 PM
This is the options file for the NONROAD program.
The data is sperated into "packets" bases on common
information. Each packet is specified by an
identifier and a terminator. Any notes or descriptions
can be placed between the data packets.

PERIOD PACKET

This is the packet that defines the period for
which emissions are to be estimated. The order of the
records matter. The selection of certain parameters
will cause some of the record that follow to be ignored.
The order of the records is as follows:

1 - Char 10 - Period type for this simulation.
Valid responses are: ANNUAL, SEASONAL, and MONTHLY
2 - Char 10 - Type of inventory produced.
Valid responses are: TYPICAL DAY and PERIOD TOTAL
3 - Integer - year of episode (4 digit year)
4 - Char 10 - Month of episode (use complete name of month)
5 - Char 10 - Type of day
Valid responses are: WEEKDAY and WEEKEND

/PERIOD/
Period type : Seasonal
Summation type : Typical day

Year of episode : 1996
Season of year : Summer
Month of year :
Weekday or weekend : Weekday
/END/

OPTIONS PACKET

This is the packet that defines some of the user
options that drive the model. Most parameters are
used to make episode specific emission factor
adjustments. The order of the records is fixed.
The order is as follows.

1 - Char 80 - First title on reports
2 - Char 80 - Second title on reports
3 - Real 10 - Fuel RVP of gasoline for this simulation
4 - Real 10 - Oxygen weight percent of gasoline for simulation
5 - Real 10 - Percent sulfur for gasoline
6 - Real 10 - Percent sulfur for diesel
7 - Real 10 - Percent sulfur for LPG/CNG
8 - Real 10 - Minimum daily temperature (deg. F)
9 - Real 10 - maximum daily temperature (deg. F)
10 - Real 10 - Representative average daily temperature (deg. F)
11 - Char 10 - Flag to determine if region is high altitude
Valid responses are: HIGH and LOW
12 - Char 10 - Flag to determine if RFG adjustments are made

Valid responses are: YES and NO

/OPTIONS/
Title 1 : Dallas Base Case
Title 2 : DFW NONROAD
Fuel RVP for gas : 7.2
Oxygen Weight % : 0.0
Gas sulfur % : 0.034
Diesel sulfur % : 0.33
CNG/LPG sulfur % : 0.003
Minimum temper. (F): 80
Maximum temper. (F): 101
Average temper. (F): 94
Altitude of region : LOW
/END/

REGION PACKET

This is the packet that defines the region for which emissions are to be estimated.

The first record tells the type of region and allocation to perform.

Valid responses are:
US TOTAL - emissions are for entire USA without state breakout.

50STATE - emissions are for all 50 states
and Washington D.C., by state.

STATE - emissions are for a select group of states
and are state-level estimates

COUNTY - emissions are for a select group of counties
and are county level estimates. If necessary,
allocation from state to county will be performed.

SUBCOUNTY - emissions are for the specified sub counties
and are subcounty level estimates. If necessary,
county to subcounty allocation will be performed.

The remaining records define the regions to be included.
The type of data which must be specified depends on the
region level.

US TOTAL - Nothing needs to be specified. The FIPS
code 00000 is used automatically.

50STATE - Nothing needs to be specified. The FIPS
code 00000 is used automatically.

STATE - state FIPS codes

COUNTY - state or county FIPS codes. State FIPS
code means include all counties in the

state.

SUBCOUNTY - county FIPS code and subregion code.

/REGION/
Region Level : COUNTY
Collin County TX : 48085
Dallas County TX : 48113
Denton County TX : 48121
Tarrant County TX : 48439
/END/

or use -
Region Level : STATE
Michigan : 26000

SOURCE CATEGORY PACKET

This packet is used to tell the model which source
categories are to be processed. It is optional.
If used, only those source categories list will
appear in the output data file. If the packet is
not found, the model will process all source
categories in the population files.

All Equipment - just put semicolon at start of packet name line
or use the following SCC list -

:2260000000
:2265000000
:2267000000
:2268000000
:2270000000
:2282000000
:2285000000

Diesel Only -

:2270000000
:2282020000
:2285002015

Spark Ignition Only -

:2260000000
:2265000000
:2267000000
:2268000000
:2282005010
:2282005015
:2282010005
:2285004015

This is the packet that lists the names of output files
and some of the input data files read by the model. If
a drive:\path\ is not given, the location of the
NONROAD.EXE file itself is assumed. You will probably
want to change the names of the Output and Message files
to match that of the OPTion file, e.g., MICH-97.OPT,
MICH-97.OUT, MICH-97.MSG, and if used MICH-97.AMS.

```
-----------------------------------------------------
/RUNFILES/
ALLOC XREF        : C:\NONROAD\DATA\ALLOCATE\ALLOCATE.XRF
ACTIVITY          : C:\NONROAD\DATA\ACTIVITY\ACTIVITY.DAT
TECHNOLOGY        : C:\NONROAD\DATA\TECH\TECH.DAT
SEASONALITY       : C:\NONROAD\DATA\SEASON\SEASON.DAT
REGIONS           : C:\NONROAD\DATA\SEASON\SEASON.DAT
MESSAGE           : c:\nonroad\outputs\DFW96.msg
OUTPUT DATA       : c:\nonroad\outputs\DFW96.out
EPS2 AMS          :
/END/

-----------------------------------------------------
This is the packet that defines the equipment population
files read by the model.
-----------------------------------------------------
/POP FILES/
Population File : c:\nonroad\data\POP\TX.POP
/END/

POPULATION FILE    : c:\nonroad\data\POP\MI.POP


-----------------------------------------------------
This is the packet that defines the growth files
files read by the model.
-----------------------------------------------------
/GROWTH FILES/
National defaults  :C:\nonroad\data\growth\nation.grw
```

/END/

This is the packet that defines the spatial
allocation files read by the model.

/ALLOC FILES/
Allocation File : c:\nonroad\data\ALLOCATE\TX_RVPRK.ALO
Allocation File : c:\nonroad\data\ALLOCATE\TX_GOLF.ALO
Allocation File : c:\nonroad\data\ALLOCATE\TX_AIRTR.ALO
Allocation File : c:\nonroad\data\ALLOCATE\TX_CONST.ALO
Allocation File : c:\nonroad\data\ALLOCATE\TX_FARMS.ALO
Allocation File : c:\nonroad\data\ALLOCATE\TX_HOLSL.ALO
Allocation File : c:\nonroad\data\ALLOCATE\TX_HOUSE.ALO
Allocation File : c:\nonroad\data\ALLOCATE\TX_LOGGN.ALO
Allocation File : c:\nonroad\data\ALLOCATE\TX_LSCAP.ALO
Allocation File : c:\nonroad\data\ALLOCATE\TX_METAL.ALO
Allocation File : c:\nonroad\data\ALLOCATE\TX_MNFG.ALO
Allocation File : c:\nonroad\data\ALLOCATE\TX_OIL.ALO
Allocation File : c:\nonroad\data\ALLOCATE\TX_POP.ALO
Allocation File : c:\nonroad\data\ALLOCATE\TX_WATER.ALO
/END/

This is the packet that defines the emssions factors
files read by the model.

/EMFAC FILES/
THC exhaust : C:\nonroad\data\emsfac\exhthc.emf

```
CO exhaust        : C:\nonroad\data\emsfac\exhco.emf
NOX exhaust       : C:\nonroad\data\emsfac\exhnox.emf
PM exhaust        : C:\nonroad\data\emsfac\exhpm.emf
BSFC              : C:\nonroad\data\emsfac\bsfc.emf
Crankcase         : C:\nonroad\data\emsfac\crank.emf
Spillage          : C:\nonroad\data\emsfac\spillage.emf
Diurnal           : C:\nonroad\data\emsfac\diurnal.emf
/END/

-----------------------------------------------------
This is the packet that defines the deterioration factors
files read by the model.
-----------------------------------------------------
/DETERIORATE FILES/
THC exhaust       : C:\nonroad\data\detfac\exhthc.det
CO exhaust        : C:\nonroad\data\detfac\exhco.det
NOX exhaust       : C:\nonroad\data\detfac\exhnox.det
PM exhaust        : C:\nonroad\data\detfac\exhpm.det
/END/

Optional Packets - Add initial slash "/" to activate

/STAGE II/
Control Factor    : 81
/END/
Enter percent control: 95 = 95% control = 0.05 x uncontrolled
Default should be zero control.

MODELYEAR OUT/
```

```
by-model-year out  : C:\nonroad\outputs\template.bmy
/END/

SI REPORT/
SI report file-CSV :C:\NONROAD\OUTPUTS\NRPOLLUT.CSV
/END/
```

SCC	EQUIP	HPMN	HPMX	HOU_POP	NR_POP	DEFAULT	RATIOS CC	HOU_SCC	ADJUST	RICK_POP	NONROAD
2270002003	Pavers	16	25	456	16	2228	0.01	3	4.8854	3	15
2270002003	Pavers	25	40	456	587	2228	0.26	120	4.8854	12	59
2270002003	Pavers	40	50	456	119	2228	0.05	24	4.8854	6	29
2270002003	Pavers	50	100	456	643	2228	0.29	132	4.8854	4	20
2270002003	Pavers	100	175	456	720	2228	0.32	147	4.8854	81	396
2270002003	Pavers	175	300	456	124	2228	0.06	25	4.8854	100	489
2270002003	Pavers	300	600	456	19	2228	0.01	4	4.8854	1	5
2270002009	Plate Compactors	3	6	128	248	627	0.40	51	4.8984	51	248
2270002009	Plate Compactors	6	11	128	324	627	0.52	66	4.8984	66	324
2270002009	Plate Compactors	11	16	128	43	627	0.07	9	4.8984	9	43
2270002009	Plate Compactors	16	25	128	12	627	0.02	3	4.8984	3	12
2270002015	Rollers	3	6	1571	33	7678	0.00	7	4.8875	7	33
2270002015	Rollers	6	11	1571	183	7678	0.02	37	4.8875	37	183
2270002015	Rollers	11	16	1571	183	7678	0.02	37	4.8875	37	183
2270002015	Rollers	16	25	1571	71	7678	0.01	15	4.8875	15	71
2270002015	Rollers	25	40	1571	592	7678	0.08	121	4.8875	104	508
2270002015	Rollers	40	50	1571	371	7678	0.05	76	4.8875	53	259
2270002015	Rollers	50	100	1571	2789	7678	0.36	571	4.8875	544	2659
2270002015	Rollers	100	175	1571	3139	7678	0.41	642	4.8875	954	4663
2270002015	Rollers	175	300	1571	290	7678	0.04	59	4.8875	43	210
2270002015	Rollers	300	600	1571	27	7678	0.00	5	4.8875	2	10
2270002018	Scrapers	50	100	518	9	2530	0.00	2	4.8842	1	5
2270002018	Scrapers	100	175	518	445	2530	0.18	91	4.8842	1	5
2270002018	Scrapers	175	300	518	812	2530	0.32	166	4.8842	31	151
2270002018	Scrapers	300	600	518	1052	2530	0.42	215	4.8842	3	15
2270002018	Scrapers	600	750	518	212	2530	0.08	43	4.8842	1	5
2270002021	Paving Equipment	11	16	636	10	3108	0.00	2	4.8868	2	10
2270002021	Paving Equipment	16	25	636	81	3108	0.03	17	4.8868	17	81
2270002021	Paving Equipment	25	40	636	135	3108	0.04	28	4.8868	1	5
2270002021	Paving Equipment	40	50	636	19	3108	0.01	4	4.8868	7	34
2270002021	Paving Equipment	50	100	636	1377	3108	0.44	282	4.8868	28	137
2270002021	Paving Equipment	100	175	636	1213	3108	0.39	248	4.8868	13	64

2270002021	Paving Equipment		175	300	636	273	3108	0.09	56	4.8868	41	200
2270002024	Surfacing Equipment		16	25	71	37	345	0.11	8	4.8592	8	37
2270002024	Surfacing Equipment		100	175	71	29	345	0.08	6	4.8592	154	748
2270002024	Surfacing Equipment		175	300	71	24	345	0.07	5	4.8592	12	58
2270002024	Surfacing Equipment		300	600	71	222	345	0.64	46	4.8592	208	1011
2270002024	Surfacing Equipment		600	750	71	33	345	0.10	7	4.8592	16	78
2270002027	Signal Plants	Boards/Light	3	6	920	891	4495	0.20	182	4.8861	182	891
2270002027	Signal Plants	Boards/Light	6	11	920	1499	4495	0.33	307	4.8861	307	1499
2270002027	Signal Plants	Boards/Light	11	16	920	394	4495	0.09	81	4.8861	81	394
2270002027	Signal Plants	Boards/Light	16	25	920	1390	4495	0.31	284	4.8861	284	1390
2270002027	Signal Plants	Boards/Light	25	40	920	118	4495	0.03	24	4.8861	157	767
2270002027	Signal Plants	Boards/Light	40	50	920	1	4495	0.00	0	4.8861	0	1
2270002027	Signal Plants	Boards/Light	50	100	920	110	4495	0.02	22	4.8861	0	0
2270002027	Signal Plants	Boards/Light	100	175	920	77	4495	0.02	16	4.8861	0	0
2270002027	Signal Plants	Boards/Light	175	300	920	15	4495	0.00	3	4.8861	0	0
2270002030	Trenchers		6	11	1281	35	6261	0.01	7	4.8872	7	35
2270002030	Trenchers		11	16	1281	48	6261	0.01	10	4.8872	10	48
2270002030	Trenchers		16	25	1281	44	6261	0.01	9	4.8872	9	44
2270002030	Trenchers		25	40	1281	1618	6261	0.26	331	4.8872	19	93
2270002030	Trenchers		40	50	1281	1122	6261	0.18	230	4.8872	82	401
2270002030	Trenchers		50	100	1281	2877	6261	0.46	589	4.8872	127	621
2270002030	Trenchers		100	175	1281	402	6261	0.06	82	4.8872	4	20
2270002030	Trenchers		175	300	1281	70	6261	0.01	14	4.8872	4	20
2270002030	Trenchers		300	600	1281	38	6261	0.01	8	4.8872	4	20
2270002030	Trenchers		600	750	1281	5	6261	0.00	1	4.8872	2	10
2270002030	Trenchers		1000	1500	1281	1	6261	0.00	0	4.8872	0	0
2270002033	Bore/Drill Rigs		6	11	254	9	1243	0.01	2	4.8941	2	9

2270002033	Bore/Drill Rigs	11	16	254	1	1243	0.00	0	4.8941	0	1
2270002033	Bore/Drill Rigs	16	25	254	26	1243	0.02	5	4.8941	5	26
2270002033	Bore/Drill Rigs	25	40	254	156	1243	0.13	32	4.8941	4	20
2270002033	Bore/Drill Rigs	40	50	254	22	1243	0.02	4	4.8941	1	5
2270002033	Bore/Drill Rigs	50	100	254	370	1243	0.30	76	4.8941	28	137
2270002033	Bore/Drill Rigs	100	175	254	196	1243	0.16	40	4.8941	10	49
2270002033	Bore/Drill Rigs	175	300	254	210	1243	0.17	43	4.8941	163	798
2270002033	Bore/Drill Rigs	300	600	254	163	1243	0.13	33	4.8941	1	5
2270002033	Bore/Drill Rigs	600	750	254	44	1243	0.04	9	4.8941	1	5
2270002033	Bore/Drill Rigs	750	1000	254	46	1243	0.04	9	4.8941	0	0
2270002036	Excavators	11	16	1772	197	8658	0.02	40	4.8861	40	197
2270002036	Excavators	16	25	1772	371	8658	0.04	76	4.8861	76	371
2270002036	Excavators	25	40	1772	551	8658	0.06	113	4.8861	61	298
2270002036	Excavators	40	50	1772	167	8658	0.02	34	4.8861	42	205
2270002036	Excavators	50	100	1772	1065	8658	0.12	218	4.8861	260	1270
2270002036	Excavators	100	175	1772	3812	8658	0.44	780	4.8861	869	4246
2270002036	Excavators	175	300	1772	2168	8658	0.25	444	4.8861	754	3684
2270002036	Excavators	300	600	1772	309	8658	0.04	63	4.8861	170	831
2270002036	Excavators	600	750	1772	10	8658	0.00	2	4.8861	2	10
2270002036	Excavators	750	1000	1772	7	8658	0.00	1	4.8861	0	0
2270002036	Excavators	1500	2000	1772	3	8658	0.00	1	4.8861	0	0
2270002039	Concrete/Industrial Saws	6	11	38	23	184	0.12	5	4.8493	5	23
2270002039	Concrete/Industrial Saws	16	25	38	4	184	0.02	1	4.8493	1	4
2270002039	Concrete/Industrial Saws	25	40	38	34	184	0.18	7	4.8493	18	87
2270002039	Concrete/Industrial Saws	40	50	38	18	184	0.10	4	4.8493	10	48
2270002039	Concrete/Industrial Saws	50	100	38	86	184	0.47	18	4.8493	67	325
2270002039	Concrete/Industrial Saws	100	175	38	20	184	0.11	4	4.8493	11	53
2270002042	Cement & Mortar Mixers	6	11	88	279	430	0.65	57	4.8872	57	279
2270002042	Cement & Mortar Mixers	11	16	88	107	430	0.25	22	4.8872	22	107
2270002042	Cement & Mortar Mixers	16	25	88	43	430	0.10	9	4.8872	9	43
2270002042	Cement & Mortar Mixers	50	100	88	2	430	0.00	0	4.8872	0	2
2270002045	Cranes	16	25	1480	0	7235	0.00	0	4.8887	0	0
2270002045	Cranes	25	40	1480	0	7235	0.00	0	4.8887	0	0
2270002045	Cranes	40	50	1480	138	7235	0.02	28	4.8887	28	138
2270002045	Cranes	50	100	1480	1055	7235	0.15	216	4.8887	216	1055

2270002045	Cranes	100	175	1480	2897	7235	0.40	593	4.8887	593	2897
2270002045	Cranes	175	300	1480	2465	7235	0.34	504	4.8887	504	2465
2270002045	Cranes	300	600	1480	645	7235	0.09	132	4.8887	132	645
2270002045	Cranes	600	750	1480	34	7235	0.00	7	4.8887	8	39
2270002048	Graders	25	40	1256	30	6137	0.00	6	4.8863	3	15
2270002048	Graders	40	50	1256	7	6137	0.00	1	4.8863	2	10
2270002048	Graders	50	100	1256	216	6137	0.04	44	4.8863	60	293
2270002048	Graders	100	175	1256	3337	6137	0.54	683	4.8863	459	2243
2270002048	Graders	175	300	1256	2545	6137	0.41	521	4.8863	144	704
2270002048	Graders	600	750	1256	2	6137	0.00	1	4.8863	2	10
2270002051	Off-highway Trucks	100	175	364	12	1779	0.01	2	4.8866	8	39
2270002051	Off-highway Trucks	175	300	364	372	1779	0.21	76	4.8866	10	49
2270002051	Off-highway Trucks	300	600	364	706	1779	0.40	145	4.8866	0	0
2270002051	Off-highway Trucks	600	750	364	304	1779	0.17	62	4.8866	0	0
2270002051	Off-highway Trucks	750	1000	364	177	1779	0.10	36	4.8866	39	191
2270002051	Off-highway Trucks	1000	1500	364	77	1779	0.04	16	4.8866	0	0
2270002051	Off-highway Trucks	1500	2000	364	109	1779	0.06	22	4.8866	0	0
2270002051	Off-highway Trucks	2000	3000	364	22	1779	0.01	5	4.8866	0	0
2270002054	Crushing/Proc. Equipment	16	25	140	36	682	0.05	7	4.8720	7	36
2270002054	Crushing/Proc. Equipment	25	40	140	52	682	0.08	11	4.8720	0	0
2270002054	Crushing/Proc. Equipment	40	50	140	95	682	0.14	19	4.8720	0	0
2270002054	Crushing/Proc. Equipment	50	100	140	294	682	0.43	60	4.8720	0	0
2270002054	Crushing/Proc. Equipment	100	175	140	128	682	0.19	26	4.8720	0	0
2270002054	Crushing/Proc. Equipment	175	300	140	30	682	0.04	6	4.8720	0	0
2270002054	Crushing/Proc. Equipment	300	600	140	47	682	0.07	10	4.8720	0	0
2270002054	Crushing/Proc. Equipment	600	750	140	1	682	0.00	0	4.8720	0	0
2270002057	Rough Terrain Forklifts	25	40	1212	13	5922	0.00	3	4.8863	3	14
2270002057	Rough Terrain Forklifts	40	50	1212	72	5922	0.01	15	4.8863	7	34
2270002057	Rough Terrain Forklifts	50	100	1212	3880	5922	0.66	794	4.8863	374	1827
2270002057	Rough Terrain Forklifts	100	175	1212	1865	5922	0.31	382	4.8863	101	494
2270002057	Rough Terrain Forklifts	175	300	1212	72	5922	0.01	15	4.8863	1	5
2270002057	Rough Terrain Forklifts	300	600	1212	20	5922	0.00	4	4.8863	1	5
2270002060	Rubber Tire Loaders	6	11	3192	34	15599	0.00	7	4.8870	7	34
2270002060	Rubber Tire Loaders	16	25	3192	45	15599	0.00	9	4.8870	9	45
2270002060	Rubber Tire Loaders	25	40	3192	38	15599	0.00	8	4.8870	2	10

2270002060	Rubber Tire Loaders	40	50	3192	154	15599	0.01	31	4.8870	6	29
2270002060	Rubber Tire Loaders	50	100	3192	4325	15599	0.28	885	4.8870	55	269
2270002060	Rubber Tire Loaders	100	175	3192	6313	15599	0.40	1292	4.8870	659	3221
2270002060	Rubber Tire Loaders	175	300	3192	3836	15599	0.25	785	4.8870	380	1857
2270002060	Rubber Tire Loaders	300	600	3192	651	15599	0.04	133	4.8870	2	10
2270002060	Rubber Tire Loaders	600	750	3192	147	15599	0.01	30	4.8870	2	10
2270002060	Rubber Tire Loaders	750	1000	3192	12	15599	0.00	3	4.8870	0	0
2270002060	Rubber Tire Loaders	1000	1500	3192	13	15599	0.00	3	4.8870	0	0
2270002060	Rubber Tire Loaders	1500	2000	3192	27	15599	0.00	5	4.8870	0	0
2270002060	Rubber Tire Loaders	2000	3000	3192	3	15599	0.00	1	4.8870	0	0
2270002063	R u b b e r T i r e Tractor/Dozers	100	175	85	6	413	0.01	1	4.8647	90	438
2270002063	R u b b e r T i r e Tractor/Dozers	175	300	85	167	413	0.40	34	4.8647	2	10
2270002063	R u b b e r T i r e Tractor/Dozers	300	600	85	234	413	0.56	48	4.8647	20	97
2270002063	R u b b e r T i r e Tractor/Dozers	600	750	85	2	413	0.00	0	4.8647	0	2
2270002063	R u b b e r T i r e Tractor/Dozers	750	1000	85	5	413	0.01	1	4.8647	0	0
2270002066	Tractors/Loaders/Backhoes	11	16	5107	2	24958	0.00	0	4.8870	0	2
2270002066	Tractors/Loaders/Backhoes	16	25	5107	97	24958	0.00	20	4.8870	20	97
2270002066	Tractors/Loaders/Backhoes	25	40	5107	226	24958	0.01	46	4.8870	120	586
2270002066	Tractors/Loaders/Backhoes	40	50	5107	799	24958	0.03	163	4.8870	40	195
2270002066	Tractors/Loaders/Backhoes	50	100	5107	18041	24958	0.72	3692	4.8870	2748	13430
2270002066	Tractors/Loaders/Backhoes	100	175	5107	5792	24958	0.23	1185	4.8870	334	1632
2270002066	Tractors/Loaders/Backhoes	175	300	5107	1	24958	0.00	0	4.8870	20	98
2270002069	Crawler Tractor/Dozers	25	40	3423	34	16728	0.00	7	4.8869	6	29
2270002069	Crawler Tractor/Dozers	40	50	3423	7	16728	0.00	1	4.8869	4	20
2270002069	Crawler Tractor/Dozers	50	100	3423	7242	16728	0.43	1482	4.8869	1008	4926
2270002069	Crawler Tractor/Dozers	100	175	3423	4825	16728	0.29	987	4.8869	670	3274

2270002069	Crawler Tractor/Dozers	175	300	3423	3433	16728	0.21	702	4.8869	399	1950
2270002069	Crawler Tractor/Dozers	300	600	3423	817	16728	0.05	167	4.8869	18	88
2270002069	Crawler Tractor/Dozers	600	750	3423	270	16728	0.02	55	4.8869	2	10
2270002069	Crawler Tractor/Dozers	750	1000	3423	100	16728	0.01	21	4.8869	0	0
2270002072	Skid Steer Loaders	11	16	4641	1495	22682	0.07	306	4.8873	306	1495
2270002072	Skid Steer Loaders	16	25	4641	2882	22682	0.13	590	4.8873	590	2882
2270002072	Skid Steer Loaders	25	40	4641	6033	22682	0.27	1234	4.8873	49	239
2270002072	Skid Steer Loaders	40	50	4641	2726	22682	0.12	558	4.8873	172	841
2270002072	Skid Steer Loaders	50	100	4641	9530	22682	0.42	1950	4.8873	1184	5787
2270002072	Skid Steer Loaders	100	175	4641	15	22682	0.00	3	4.8873	2	10
2270002075	Off-Highway Tractors	100	175	479	794	2342	0.34	162	4.8898	3	15
2270002075	Off-Highway Tractors	175	300	479	881	2342	0.38	180	4.8898	3	15
2270002075	Off-Highway Tractors	300	600	479	110	2342	0.05	23	4.8898	1	5
2270002075	Off-Highway Tractors	600	750	479	470	2342	0.20	96	4.8898	2	10
2270002075	Off-Highway Tractors	750	1000	479	60	2342	0.03	12	4.8898	0	0
2270002075	Off-Highway Tractors	1000	1500	479	26	2342	0.01	5	4.8898	0	0
2270002078	Dumpers/Tenders	16	25	5	25	25	1.00	5	5.0939	5	25
2270002081	Other Construction Equipment	6	11	223	165	1087	0.15	34	4.8758	34	165
2270002081	Other Construction Equipment	11	16	223	128	1087	0.12	26	4.8758	26	128
2270002081	Other Construction Equipment	16	25	223	114	1087	0.10	23	4.8758	23	114
2270002081	Other Construction Equipment	25	40	223	87	1087	0.08	18	4.8758	20	98
2270002081	Other Construction Equipment	40	50	223	9	1087	0.01	2	4.8758	6	29
2270002081	Other Construction Equipment	50	100	223	45	1087	0.04	9	4.8758	145	707
2270002081	Other Construction Equipment	100	175	223	214	1087	0.20	44	4.8758	74	361
2270002081	Other Construction Equipment	175	300	223	141	1087	0.13	29	4.8758	50	244
2270002081	Other Construction Equipment	300	600	223	185	1087	0.17	38	4.8758	56	273
				29,340	143,383	143,378		29,341		18,720	91,468

20.46%

63.80% 63.79%